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The Journal of Bone and Joint Surgery

EDWARD HICKLING BRADFORD

The world recognizes that important service given by a man to his fellow men makes him great. If this man exhibits a constant and chivalrous courage while he serves, the world adjudges him still greater. To possess humility when both a man's service and his courage are honored is the epitome of greatness. Such greatness of mind and heart and soul shaped the life of Edward Hickling Bradford. It is fitting that we should review his many services, trying to catch his brave spirit and to fix the memory of his unselfishness, for "he saw life steadily and saw it whole".

The strong hereditary influences of a long line of Old England and New England ancestors were evident in his character, but he yielded to the most admirable of these influences and resisted all insularity. He was broadly cosmopolitan throughout his life.

Dr. Bradford was born in 1848. Even in boyhood his sight was far from normal, yet few of his intimate friends knew of this. He asked no favor. Like each infirmity that came to him in later life, he refused to accept it as a handicap, but hailed it as a challenge. At the famous old Roxbury Latin School and later as an undergraduate at Harvard he placed proper values upon scholarship, comradeship, and sport.

He was graduated from Harvard College in 1869. After a brief trial of business, he found the call of medicine too strong to resist and received his M.D. degree from the Harvard Medical School in 1873. He had managed during his medical course to earn an M.A. as well in 1872. A House Officership at the Massachusetts General Hospital was followed by a period of study abroad, longest at Vienna, but with short courses in Paris, London, and Berlin. This period of his life he always looked back upon with greatest pleasure, shared as it was with such choice spirits and close friends as Frederick C. Shattuck of Boston and William Bull of New York. Returning to Boston, full of enthusiasm, he was appointed to the Staff of the Boston Dispensary in 1876 and to the Staff of the Boston Children's Hospital in 1878. Later he became Out-Patient Surgeon

to the Boston City Hospital, and in 1885 was made one of the Visiting Staff. For many years he remained one of the most active and able of that famous group, Cheever, Homans, Gay, Bolles, and Post. Always open to new ideas, he eagerly adopted the antiseptic technique of Lister and the subsequent advances toward asepsis. His judgment was keen and his surgery bold. He was the first surgeon at the City Hospital to attack a tumor of the brain. He gradually became more and more interested in bone and joint surgery and nearly all orthopaedic cases were referred to him. One of his contemporaries on the Staff describes him in these early days as broadminded, generous hearted, free from jealousy, the first to congratulate an associate and the last to criticize his fellows.

A fine training, recognized ability, strong inclination, opened wide the doors of opportunity in general surgery to him.

> "Till a voice as bad as Conscience rang interminable changes,
> On one everlasting whisper day and night repeated—so:
> 'Something hidden: Go and find it. Go and look behind the Ranges,—
> Something lost behind the Ranges. Lost and waiting for you. Go!' "

Like the explorer, he found rich country behind the Ranges and lived to see other men follow along the trails he blazed. He was one of the architects who dignified the building of a special branch of surgery and he witnessed the growth of a large community of effort.

At The House of the Good Samaritan in Boston, Dr. Buckminster Brown had established in 1861 the first ward in America for the exclusive treatment of orthopaedic cases. Here Dr. Bradford began his specialized work with the man who was the first American surgeon to limit his practice to this much neglected field and, impressed by the importance of segregating such cases, he was chiefly responsible for the development of a larger Orthopaedic Service at the Children's Hospital and for the introduction of specialized teaching along these lines in the Harvard Medical School. He became the head of this important service at the Children's Hospital and attracted Lovett, Brackett, Goldthwait, Thorndike, and a host of younger men to work with him. He eventually gave up all his other hospital appointments and at the beginning of the century confined his work to his chosen field of surgery.

At the Medical School he was appointed Assistant in Clinical Surgery in 1881; Assistant Professor of Orthopaedic Surgery in 1889, and became first full Professor of Orthopaedic Surgery in 1903, occupying the Chair until 1912. In his lectures he made use of the visual as well as the didactic approach to the student's mind. He gradually assembled a unique and comprehensive collection of lantern slides of orthopaedic conditions, of primitive races and of gaits and of ancient and modern footwear. With this collection he illustrated his talks. In the clinics he was determined that the students should do things themselves, that they should feel the lesion as well as hear of it, and in so far as possible should treat it. "*Morbi non eloquentia sed remediis curantur.*" So his teaching was profitable and popular, which is a not too common combination.

In 1887, feeling the need for some national association to foster the growth and raise the standards of work in this fast developing specialty, he joined with Gibney and Shaffer and others in New York in founding the American Orthopaedic Association. He became its President in 1888, and always played an important part in shaping its policy until he was made an Honorary Member in 1915.

His scholarly mind realized that his wide experience demanded an enunciation of the principles of treatment and an exposition of the methods which he and his associates had found to be sound. This led him, in collaboration with Dr. Robert W. Lovett, to write a Textbook of Orthopaedic Surgery, which was published in 1890, became immediately a standard, and ran through many editions. The publishers have recently requested that a new edition be prepared, so strong is its hold today on the medical public.

Dr. Bradford devoted the summer of 1889 to foreign travel, and in Milan was greatly impressed by a special school for rachitic children. On his return, with characteristic initiative and energy, he busied himself with plans for the industrial as well as the academic education of crippled children. In 1893, the Boston Industrial School for Crippled and Deformed Children opened its doors. This school has been the model for many other schools throughout the country. It has grown and flourished and remains a monument to his forceful and wise humanitarianism.

The increasing demands of medical school teaching, charitable hospital work, and a large private practice never dulled this busy man's sense of civic responsibility. Convinced of the right of handicapped children to special industrial training and general education, he persuaded Governor Bates and the Legislature of the State of Massachusetts of their duty to the State's crippled minor wards. The bill authorizing the establishment of the Massachusetts Hospital School at Canton was passed and signed by the Governor in 1904. Dr. Bradford was appointed to the Board of Trustees in 1905, and served continuously as Chairman until his death, "retaining to the end the full vigor of a masterful intellect and all the kindly impulses of a warm and generous heart". His advice was usually followed in the most careful architectural and administrative planning of this large institution. The newly appointed superintendent, Dr. John E. Fish, caught his spirit and from the day on which it received its first patients in 1908 through its eighteen years of increasing usefulness these two wise men have worked hand and mind together to increase the mental development and lessen the physical handicap of the growing number of their charges. The success of their efforts in this State Hospital School may be gauged by attending an annual Alumni Day. No more inspiring reward of endeavor can be imagined than to see these young men and women return, with the zest of accomplishment showing in their faces, to pay tribute to a training and treatment which has made it possible for them to take their places with the world's workers without feeling fear or asking favor.

Dr. Bradford was a boy of twelve when the Civil War began. His remembrance of those troubled times was very fresh and he became a close student of military matters and especially of the Civil War. He was a member of the Military Historical Society. He often said that two regrets of his life were that he was born too late to enter the ranks of the war of 1860, and too early for the World War.

During the Spanish War of 1898, he was intensely active as a member of the Massachusetts Volunteer Aid Association, and with Dr. Herbert Burrell was chiefly responsible for raising the money to provide and equip the Hospital Ship "Bay State". This ship was the first of the hospital ships to reach Cuba when the need for it was crying. It continued its service throughout the war.

Dr. Bradford was greatly stirred by the events leading to the Great War. With characteristic fairness of mind he weighed the responsibilities of the participants and inevitably found himself fighting on the side of the Allies. At his age and with his handicap, realizing that his part would be better played in his own community, he threw himself into war activities without restraint and did important work on the Supervising Committee of the Selective Service Commission of the State of Massachusetts.

To many men when the rule of years requires the laying down of hospital clinic duties, the "Well done" of their peers and the "Emeritus" of their university seem to have earned for them well merited rest. To Dr. Bradford it meant only more time for more service. He accepted the Deanship of the Harvard Medical School in 1912, serving in that capacity until 1918. With undiminished vigor he applied himself to the complicated changing problems of medical education. Under his administration the school grew and prospered and assumed leadership.

He was elected to the Board of Overseers of Harvard College in 1919, and was made Chairman of its Medical Committee. He never lost touch with the students. He sought their point of view and valued their estimate of their teachers. He met them in large groups at his house and brought them in social as well as academic touch with their instructors. They could not fail to sense his purpose, his youth, and his unselfishness.

The same sense of civic responsibility that made him devote much of his time to the State Hospital School at Canton led him to accept, a year or two before his death, the chairmanship of the Conservation Commission appointed by the Mayor of Boston. The purpose of this commission was to discuss public health needs in the city and to advise as to methods of meeting them. Two days before he died he was planning a forum of experts on school ventilation.

An accident brought on increasing dimness of vision, but undaunted he took up Braille and learned to read with facility and with great pleasure.

In the face of great personal handicap his philosophy of life was summarized in a chance conversation only a week before his death, with the Rev. Dr. Peabody of Harvard. Together they had been visiting a sick friend. Speaking of his oncoming blindness, Dr. Bradford said that the

first effect of this affliction was a sense of depression. "I was tempted to take a despondent view of life, but soon, however, on reflection I realized that all this was but incidental and superficial compared with the resources of life. I found that life was a very rich opportunity which I had only half explored. I found that life itself could be nothing more than a temporary aspect of that spiritual experience in which I might prepare myself for larger service. This reflection returned to me not only courage but enjoyment of life." Dr. Bradford was never long imprisoned in "the eternal present", and his religion offered him, as Gilbert Murray says, a ready means of escape from any temporary imprisonment.

The close understanding comradeship of his wife, the high standards of integrity, scholarship, and sportsmanship of his sons and daughter made his family life completely happy. He knew, therefore, that his burning torch would be carried by able and eager hands.

The heritage he has left to Medicine is a noble heritage. It enriches Surgery in general quite as much as the special branch he developed.

His former pupils obtained his reluctant permission to have the portrait of him which precedes this tribute painted by an eminent artist and an old friend. It hangs in the Faculty Room, presented to the Medical School of Harvard University in recognition of the Service, Courage, and Humility of Edward Hickling Bradford.

T. HALSTEAD MYERS

The American Orthopaedic Association records with real sorrow the passing of Dr. T. Halstead Myers. An association with its membership of more than a quarter century has been severed, leaving memories of a personality characterized by sweetness, friendliness and kindness but also by high professional ideals and notable accomplishments in his work.

Unable to do justice to him with words, we nevertheless utter them in solace for our loss and as a feeble expression of sympathy to his bereaved family.

FRED J. FASSATT

The American Orthopaedic Association has lost an able, gentle, friendly member and the medical profession a forceful, highly trained, devoted servant in the death on March 24, 1926, of Dr. Fred J. Fassatt of Seattle, Washington.

Graduating from the School of Osteopathy, he built up a successful practice which, however, in many respects failed to satisfy him. Limiting his work to therapeutic measures which appealed to his reason and his conscience, he put himself through the Harvard Medical School from which he was graduated in 1906. He concentrated his attention upon bone and joint surgery and served with great efficiency in Boston clinics, finally settling in Seattle where he began the practice of orthopaedic surgery. He was appointed consulting orthopaedic surgeon to the Seattle City Hospital and became Chief Surgeon of the Children's Orthopaedic Hospital for the development of which he was largely responsible.

The American Orthopaedic Association elected him a member in 1917. Captain Fassatt was one of that eager band who early went over to England with Goldthwait to help hold up the tired hands of the hard pressed Sir Robert Jones, striving to care for the flood of bone and joint casualties surging back to the special centers in the British Isles.

Assigned to the Old Mill Unit at Aberdeen he upheld the highest standards of American orthopaedic surgery and was loved and respected by all of his British and American colleagues.

It requires a high degree of courage for a man and for his devoted wife to desert prosperity to follow truth. Christian finally escaping from Bypath Meadow says, "Then I thought it easier going out of the way when we are in it than going in when we are out". This Fassatt did and found a wide field for his unusual talents. He won the affectionate trust of his new colleagues and served his community with power and his country with distinction.

PRESIDENT'S ADDRESS*

BY MICHAEL HOKE, M.D., ATLANTA, GA.

Members of the American Orthopaedic Association and Guests:

I find it a bit difficult, gentlemen, to feel the dignity that is supposed to go with a position of honor. It seems to me more natural to appreciate your friendship and courtesy than the honor, distinct though it is. Frankly, if I could have my way I would tell you a good story, sit down, and proceed with this fine program. . . .

But the matter is given a different direction by your Constitution—a very dry document in which I can find none of the spirit of fellowship in work which has been such a decided influence in promoting the usefulness of this society of surgeons. There is no humor in it. Doubtless the good men who wrote it thought the fine, unexpressed traditions of service to one another, the cripple and the public, a better gift than rules, and left the humor out, knowing that there is enough humor in the daily contact of doctors with other human beings, including doctors, to warrant a little seriousness on the part of your President at this time.

Fortunately or unfortunately, a doctor's life is an intensely human event. The direction of the main road through it, and the by-paths are indicated by human contacts and personality. . . . This is my apology.

One does not have to be an old man to recall with pleasure earlier impressions if they were sound in principle and applicable to current events,—and so I remember this: When I began practice here I had little equipment except a will to work. Gradually the country people came in with their crippled children, in possession of little except the children they brought with them. There were no institutional facilities for the care of the children. Amidst the unencouraging combination of difficulties I saw three things clearly:

That without organized facilities here and elsewhere, the effort of an individual's life-time would accomplish little; that neither I nor any other man interested in the art could develop in knowledge and experience except by affiliation with this Society; and that orthopaedic surgery is very closely related to the physical well-being and economic status of thousands of people in this land, and to the happiness of those to whom the cripple is dear.

With some of the right sort of pride and very much gratification we can view the fact that this continent is now fairly well dotted with specialized orthopaedic hospitals strategically located, manned by competent staffs, giving comfort to those who need their administrations. It matters little that the public at large knows nothing of the art, the science, the

*Delivered before the American Orthopaedic Association, Atlanta, April 27, 1926.

administrative talent and fellowship there are welded together in this Association for its service; but the fact is clear that the orderly development of methods in the art and facilities for the care of the cripples in America is due to the traditions and ideals that have been fostered; to the ideas that have been let loose in this Association, and to the fellowship that has been the basis in the society of surgeons for a very real affection for a common purpose. That your work has become one of the splendid agencies among others for a better civilization on this continent cannot be disputed.

Just as the art in America developed from the stimulation of men's minds through contact in this Association, so also must it be kept alive and continue to grow through the same influence. The principles upon which it is based are varied. The types of demands upon the brain, spirit, hands, and time of those who would practice it even fairly well, are different. It is impossible for any one man or any one group of men in one community to possess so much of the right qualities in the proper blending that it be unnecessary for them to depend upon others for their development. This is evident from our history. Just as the novice must look to the seasoned thought and experience of this Society for guidance, so the older men who are leaders must continue their active interest in the Society if they would keep their minds open and properly appraise the value of their leadership, remembering that acquired talents need to be exercised just as muscles do, and forgetting never that it is easier to transmit faults than virtues to the younger staff. To you older men, myself included, I would direct the thought that our talents will remain talents, if we have any, only in response to the stimulations received here.

This Society is at present very much alive. Wishing to see it continue as it has up to the present, I give little thought to the future programs, which will at times be good, and at times not so good,—like the human nature there is in us. I care to think little of the future of methods, —whether some, like other things, will prove to have been great in their day but no longer of service, being discarded cheerfully by our successors for better things. I do not bother about the oncoming of talented minds, for Nature has a way of producing young men from decade to decade who have the will to work, a determination to search, and a vision of usefulness, which need only be appropriated and directed somewhat. It is the spirit of your Society that will make it live! . . . If one only remembers that the function of most of the accomplishments of men is to make the living conditions of mankind better and happier; if it be borne in mind that the ideas we use in doing our bit get their ultimate evaluation through the exposure to the radical and conservative comment in this Association; if one recalls to mind the fact that it is really a gift-spirit that prompts men to travel thousands of miles once a year to pass on to their fellows the things they have found useful in their clinics at home, we will bear in mind always I think the two things, upon which I feel more than any other the future of this Society depends—two qualities utterly devoid of technique, artfulness or science,—two very fascinating qualities in human

nature,—friendship and loyalty. These two qualities infused into your technical service mean much to your future. Friendship for your fellows; for the ideas they present, which may be intrinsically sound; for the aspiring young man in an isolated community who wishes to become a member of this Society that he may be more useful to the community in which he lives and works; for the younger men and women in your clinics upon whose toil much of your usefulness and reputation depends; for your Journal, which should be the written record of the best you produce, . . . loyalty to the idea that the knowledge and contribution of each one is the common possession of all; that a just pride in the accomplishment of each of us should not be isolated but also a common possession of us all.

This spirit by which the Society lives will solve the frictions, which seem to me useless; will keep it young, no matter how old; useful in our time, and transmit a heritage for the future. For after all, the best that can be said of any of us is that we were useful in our time,—a friend, and loyal to all the departments of truth while on duty. Let us be hopeful always of better conditions, and uncompromising in our demands for rectitude while on service. . . . Your Society is a very human institution. That you will demand the best there is in human nature in the conduct of its affairs, is the wish of your present President.

Path. No. 9339

Chondrosarcoma, radius. Operation 1908, Dr. Bloodgood. Attempt at complete excision, finding pleural metastasis. Death 4 months, — metastasis to lungs.

Path. No. 1815

Benign Giant-cell Tumor, lower end of radius. Amputation at Johns Hopkins Hospital 1897. Well 1926. Painting made by Dr. Harvey Cushing.

HOW TO DIAGNOSE AND TREAT A BONE LESION

I. Central Lesions.

BY JOSEPH COLT BLOODGOOD, BALTIMORE, MD.

NOTE: The second article in this series prepared for the *Journal* by Dr. Bloodgood will deal with the subject of Periosteal Lesions.—*Editor.*

We will exclude here the ordinary fracture and the typical examples of acute osteomyelitis and tuberculosis.

Latent and Healed Bone Lesions. These cases are found by the x-ray. The indication for the x-ray may be either a recent trauma, in which the picture is taken to exclude a fracture or to picture a clinical fracture, or the x-ray is taken because of some joint symptoms suggesting infectious arthritis.

Some years ago a woman of fifty entered Johns Hopkins Hospital because of multiple joint pains, and the routine x-rays revealed a central lesion of the lower epiphysis of the femur (Fig. 1). The bone shell was intact. There was little or no expansion. Both condyles were involved. The joint was normal. The patient had been unaware of any swelling, and this joint gave no more symptoms than other joints. It proved to be a chondroma. It is reported and pictured in the Journal of Radiology for March, 1920 (Fig. 15, page 216).

Then there is a group in which there is a history of trauma and there is no evidence of fracture. An x-ray is taken which shows no fracture but a definite local lesion of the bone, of which there were no definite symptoms at the time of the injury. For example, a railroad man sprains the left knee. An x-ray (Fig. 2) pictures a central lesion of the internal condyle.

The bone shell is intact. It suggests a giant-cell tumor which is the most common central tumor of the epiphysis in an adult. But, on closer examination, the man has slight flexion deformity of the affected knee. Complete extension has been restricted since ten years of age when he remembers having some indefinite trouble there. At the exploratory operation there were first encountered a thick bone shell, a thick and slightly ossified, very fibrous connective tissue lining, and a central cavity filled with clear fluid—the typical gross appearance of a bone cyst. The sections of the connective tissue lining showed osteitis fibrosa with areas of ossification. Bone cysts are rare in the epiphyses. They usually give evidence of their presence before eighteen years of age and involve the shaft. In this case we could be quite sure that the lesion antedated the trauma. Had no x-ray been taken until months after the trauma, the man would have claimed compensation for this condition.

A girl of sixteen sprains her ankle. An x-ray shows a fracture of the

FIG. 1. (Path. No. 22016)

Central chondroma lower epiphysis of femur. White female, 51. Pain and limp 7 years. Pain in other joints. X-ray taken for multiple arthritis. Operation, curetting and radium twice. Free transplant of fat into cavity. 1926, well, 10 years. (Operation at Mayo Clinic by Dr. Charles Mayo.)

FIG. 2. (Path. No. 27057)

Latent bone cyst epiphysis, internal condyle, femur, adult. Exploration, Bloodgood. 1921 Bone shell partially ossified, connective tissue lining, clear fluid. 1926, 4 years well. X-ray taken because of a recent contusion of knee. Patient has had partial flexion of the knee since age 10. (Unusual to observe bone cyst in epiphysis.)

scaphoid. It heals in good position. Some months later she has considerable pain after dancing, with tenderness over the internal malleolus. The second x-ray (Fig. 3) took in the whole tibia, while the first showed but a few centimeters above the ankle. The second x-ray pictured an ossified, central lesion of the junction of the lower and middle third of the tibia, about the size of a twenty-five cent piece, and involving about two-thirds of the shaft. It had the appearance of a healed bone cyst, which would be the most likely condition of the shaft of a young person, and which is the most common lesion of bone to undergo spontaneous ossification without symptoms. For similar case see Fig. 4 (P. N. 37442).

The most common latent lesion of bone which is coming under observation now is the bone cyst, which may be completely ossified or only partially. The second, a fracture, usually of a small bone or of the neck of the femur, and in these cases little attention is paid to the injury.

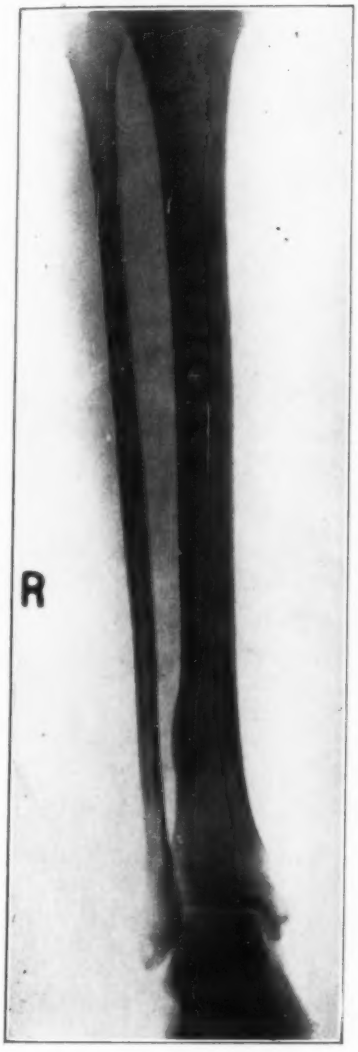

FIG. 3. (J.C.B. 14744)

Healed, ossified bone cyst, tibia lower third. Found accidentally in taking an x-ray because of pain in the foot after a sprained ankle.

FIG. 4. (Path. No. 37442)

Latent bone cyst, small, superficial, lower shaft of femur, revealed in taking x-ray for fracture, tip external head of tibia. White, male, aged 17. X-ray taken 6 weeks after fracture. Tumor in femur unnecessarily operated upon, on diagnosis of Brodie abscess or sarcoma. Sections of osteitis fibrosa with many giant-cell areas.

Up to the present time, in an individual with no previous symptoms an x-ray, taken because of a recent injury, has never revealed a giant-cell tumor, a sarcoma, or a metastatic tumor. When the injury has been associated with a fracture, cysts and metastatic tumors have been found.

Pathological Fracture. I have just studied carefully (to be published by Scudder in his new edition of Fractures) almost 130 cases of pathological

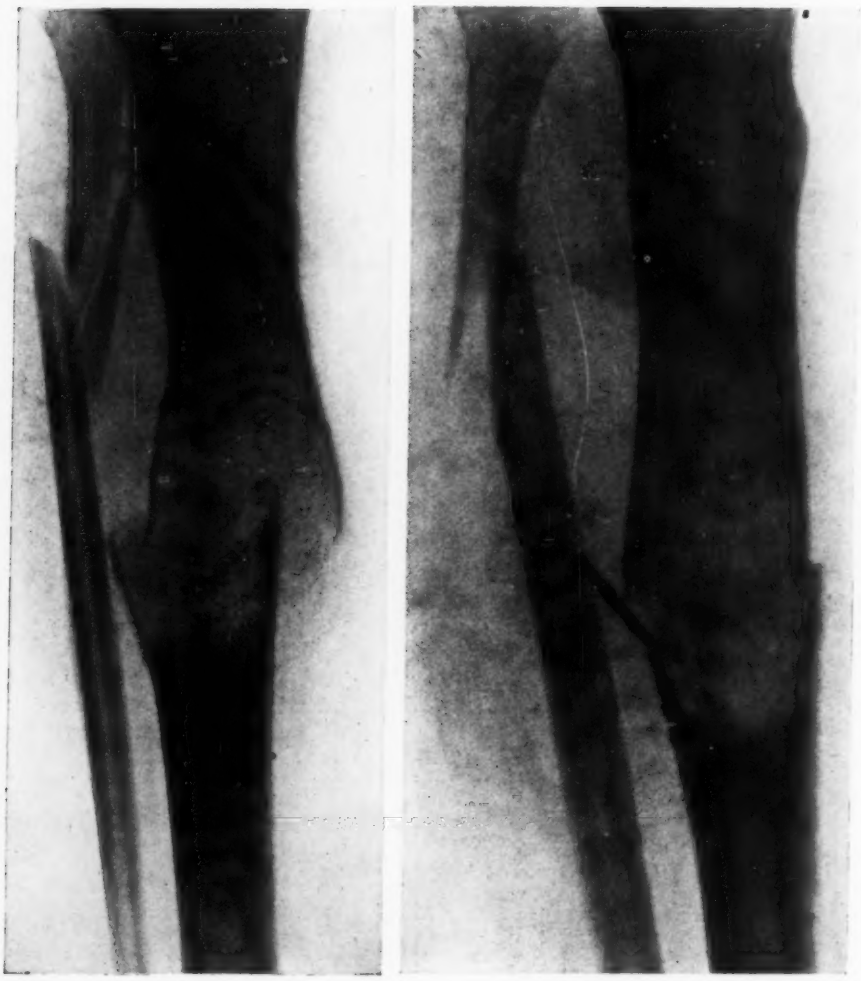

FIG. 5. (Path. No. 27375)

Bone cyst shaft of tibia, adult woman, revealed by recent fracture of both bones. Operation, Dr. Guthrie, curetting, followed by immediate ossification. Well 1926, 4 years. Patient remembered during childhood pain in this leg, and difficulty in walking with a latent period of 30 years before recent fracture.

fracture among about 1000 bone tumors. When these fractures have occurred without any previous pain, swelling, or loss of function in the bone involved, the lesions responsible for these fractures have been bone cysts or metastatic tumors of all types. In many of the metastatic cases there was no evidence and no history of a primary tumor. The chief differential point in these two classes was the age of the patient:—bone cysts in younger people (under eighteen) and the metastatic neoplasm in older people. However, there have been some exceptions in bone cysts.

Dr. Guthrie of Sayre, Pennsylvania, sent me an x-ray (Fig. 5) of a

woman over fifty who had fallen and fractured both bones of the leg in the middle third. The shaft of the fibula was fractured higher than the tibia through normal bone, while the fracture in the tibia was through a definite area of disease. There was slight expansion, a definite but thick bone shell, and an egg-shaped cavity about the size of a twenty-five cent piece. There was no history or evidence of malignant disease elsewhere. The pathology at the exploratory incision was identical with the bone cyst already mentioned—bone shell, fibrous connective tissue lining, clear fluid. It was curetted. There followed rapid ossification of the fracture.

Pathological fracture has been observed in all types of bone lesions. It is therefore not diagnostic. But the previous history is, in some cases, diagnostic. If there has been absolutely no history or evidence of pain, swelling, or disability, the probabilities are that the lesion is a bone cyst or a metastatic tumor. Up to the present time I cannot find an authentic case in which the pathological fracture was the symptom of onset in sarcoma or giant-cell tumor. In the phalanges, which are different from the long pipe bones, pathological fracture may be the first symptom of a central chondroma of the shaft, and in a very few instances of multiple myeloma fracture may be the first symptom of this fatal disease.

These cases show the importance of bearing in mind latent and healed bone lesions. They also show the value of routine x-rays immediately after injury, because if the disease is present it can have no relation to this injury.

Relation of Bone Lesions to Trauma. Some years ago an accident insurance company sent me the history of a case and some x-rays, and asked for a decision as to whether the injury had caused the bone disease evident in the x-ray. But as no x-ray had been taken directly after the injury there was no evidence to exclude a normal bone at the time of the injury. So no decision could be made.

When we go over the evidence which is getting larger and more accurate every year, we can feel gratified that the previous conceptions of the relation of trauma to lesions of bone are being confirmed.

Bone Cysts. All the evidence is against trauma as the cause of bone cysts. In fully forty per cent. of the cases the patients come under observation because of a fracture, and the cyst is present in the x-ray. In the remainder there is a history of swelling or pain, or deformity, or loss of function, and then, with or without fracture, an x-ray is taken. The osteitis fibrosa, which is the pathological process of a bone cyst, is undoubtedly an inflammatory process, which—like all such processes—tends to a spontaneous healing, but its cause has not yet been found. In pyogenic osteomyelitis trauma often localizes the bone involved. For example, in typhoid fever the organism may be widely distributed throughout the marrow tissue, but the suppuration takes place in only one or a few areas. The same is true when the organism is pyogenic. But we have no evidence that trauma can localize the bone cyst.

FIG. 6. (Path. No. 20115)

X-ray. Destructive lesion, external condyle, epiphysis left femur. Bone shell destroyed. This patient was injured July 3 and x-rays at one week intervals to August 15 showed no bone destruction. The x-ray illustrated was taken September 1. Tumor proved to be a benign giant-cell tumor. Amputation was performed under a frozen section diagnosis of sarcoma, in 1916. Patient well 1926, 10 years.

Giant-cell Tumor. Here the evidence suggests strongly that trauma may be the factor. In all recent cases, with but few exceptions, we can obtain a history of trauma. In one observation an x-ray was taken a few hours after the trauma to the knee, and for five weeks, in five x-ray pictures, the condyles of the femur appeared uninvolved. Then in the sixth week, a light area appeared in the external condyle (Fig. 6). This increased in size and, when explored in the ninth week, a giant-cell tumor was found.

Codman and others are of the opinion that the giant-cell tumor is due to hemorrhage into the bone in the cancellous tissue of the epiphysis. It leads to the disorganization and complete destruction of the bone, and there forms a vascular granulation tissue filled with foreign body giant-cells. This vascular mass may act like a glioma of the brain, but it never infiltrates in the same way. It may destroy the bone shell and may infiltrate even beyond, but it always remains encapsulated or circumscribed. Neither the glioma nor the giant-cell tumor metastasizes. Yet the glioma is still classed with neoplasms, while the giant-cell tumor is not, at least by some students. I have often felt that if a glioma started in the epiphysis of bone it would resemble a giant-cell tumor, while if a giant-cell were transplanted into the brain it would follow the course of the glioma. But the point to emphasize here is that the giant-cell tumor develops after a trauma. It may be a very slow or very rapid growth. It may destroy the bone shell very quickly, or the shell may be intact for even ten years. Pathological fracture is rare. This may be explained by its situation in the epiphysis. The common pathological fractures are in the shaft, and that is why the bone cysts and the metastatic tumors are often associated with pathologic fractures.

This contrast between the bone cyst and the giant-cell tumor must be constantly in the minds of the diagnostician, because in number these two lesions together rank second to sarcoma.

Chondroma. Myxoma. There is no evidence whatever that trauma

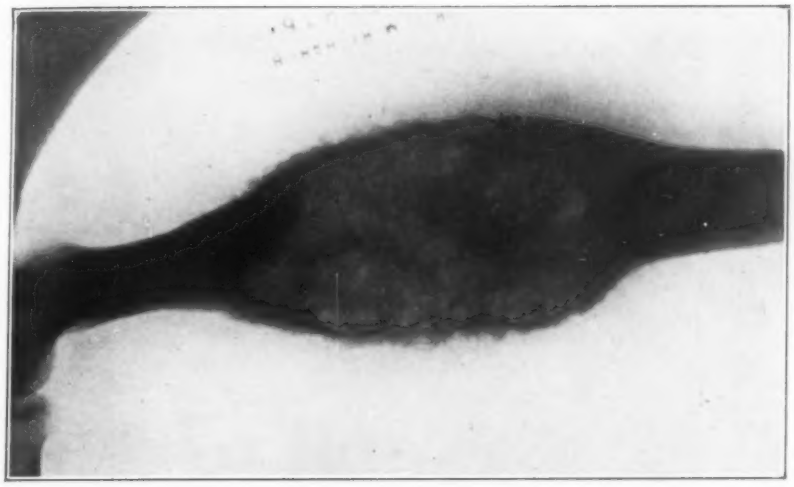

FIG. 7. (Path. No. 32415)

Central chondroma, shaft of humerus, white male, aged 52. Pain in the arm 4 years, tumor 3 months. The age is against bone cyst; the position against giant-cell tumor. The evidence of new growth in the bone shell favors chondroma and is against myxoma, sarcoma, multiple myeloma, and metastatic tumor. It should have been resected with bone transplantation. Unfortunately it was explored, diagnosed chondrosarcoma and amputation at shoulder performed in 1923. The loss of this arm in this case is a demonstration of the importance of the dissemination of knowledge on differential diagnosis.

has any relation to the growth of these tumors. The chondromas (Fig. 7) are evidently congenital residues, and one is inclined to conclude that myxomas (Figs. 8, 9, and 10) are degenerative processes in chondroma and then take up neoplastic characteristics. Both lesions may be central or periosteal. When they occur in the epiphyses in adults they are difficult to diagnose from the giant-cell tumor, but when one observes a central tumor of the shaft in an adult, one should always bear in mind the chondroma, myxoma, the metastatic tumor, and the myeloma. Central sarcomas may occur in the shaft or epiphysis, and in the majority of cases they are definitely secondary to chondroma or myxoma. Central sarcoma of any type is very infrequent as compared with the periosteal or diffuse sarcoma, and this type of sarcoma has no relation to trauma. Of course, we know that injury and irritation aggravate the growth of any neoplastic tissue.

Sarcoma. The majority of sarcomas of bone involve the entire bone, like osteomyelitis, and the common term periosteal which all of us have employed for years has been good enough to distinguish them from central lesions, but is not accurate enough to be retained. As already stated, there is a central sarcoma originating just like the bone cyst in the shaft, or the giant-cell tumor in the epiphysis. The majority of these are myxosarcomas or chondrosarcomas (Fig. 11). The few remaining central sarcomas classed in older literature as bone aneurysms need restudy. I feel sure that most

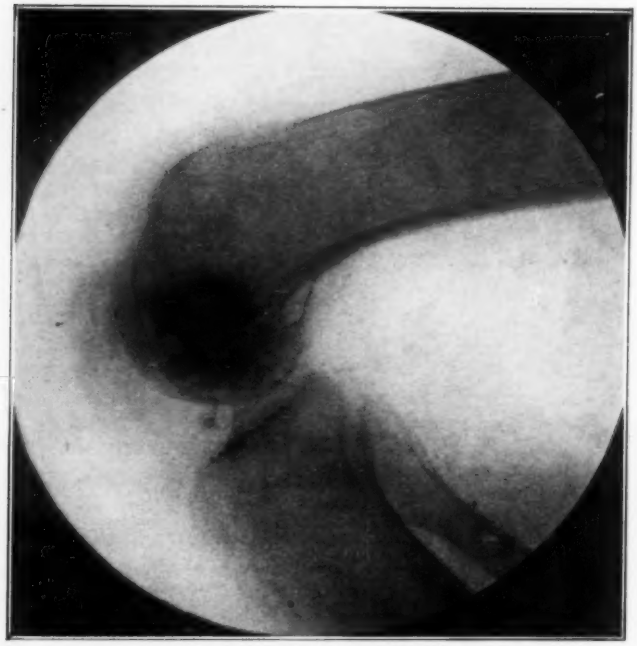

FIG. 8. (Path. No. 27159)

Lateral view of what I diagnosed as an ossified lesion in the external condyle of the epiphysis of the femur. The x-ray was taken in 1920 because of pain in the knee. (For antero-posterior view see Fig. 9.)

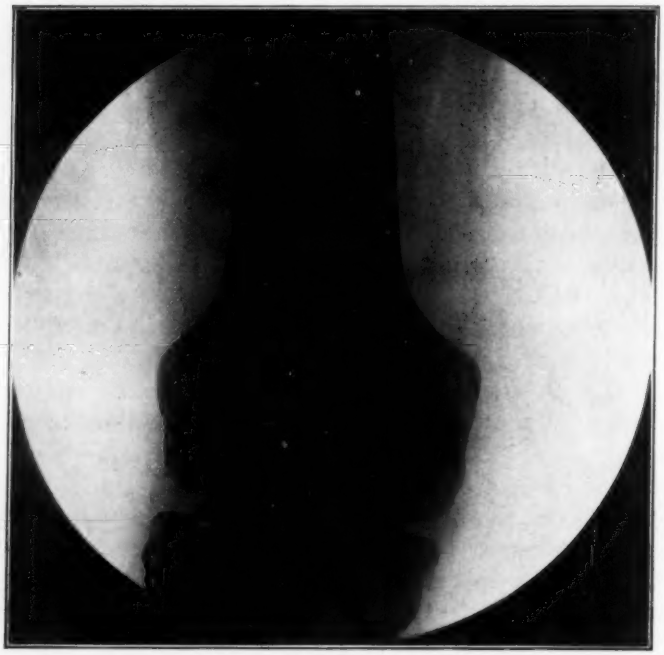

FIG. 9. (Path. No. 27159)

(See Fig. 8.) Patient, aged 41, had pain in the left knee for 14 years with no restriction of motion. It never occurred to me that it was a latent malignant tumor. In 1924, 4 years later, the leg was amputated for a myxosarcoma. (See Fig. 10.)

FIG. 10. (Path. No. 34522)

This x-ray was taken 4 years after Figs. 8 and 9. The remains of the old lesion are seen. In addition, a destructive central lesion extending up the epiphysis and shaft with some new periosteal bone formation. The patient has had intense pain for last 6 weeks. Deep x-ray therapy did not relieve pain. Amputation was done. Patient is well 1926, 2 years. (This case has been published in the Annals of Surgery.)

of them were giant-cell tumors (Fig. 12). As a few died of metastasis the question which is yet unanswered is: Were they malignant giant-cell tumors, or osteogenic sarcomas, or angio sarcomas originating in the marrow?

There is no doubt that there is a true periosteal sarcoma,—one that begins outside the bone either from the periosteal layer, or the connective tissue adjacent to it. And there are two types: the well recognized fibrosarcoma which is not associated with ossification and an osteogenic sarcoma which is usually associated with some periosteal bone formation and later with cortical destruction. But this latter periosteal sarcoma may perforate into the marrow through the haversian system and produce marrow tumors without any changes in the cortical bone to be seen in the x-ray.

Diffuse Sarcoma. There are two distinct types in the x-ray: the sclerosing which may be associated with excessive periosteal bone formation, and the osteoporosis type, which rapidly becomes destructive. Periosteal bone formation in this type is never marked. Sclerosing sarcoma is more common than the osteoporosis. Both give a somewhat typical x-ray picture and should be diagnosed, with rare exceptions, from the x-ray. I know of no x-ray picture resembling the sclerosing sarcoma. The osteoporosis of none-use is not unlike the osteoporosis type of sarcoma, but in the sarcoma there is no history of non-use, and the shaft is usually involved, while in the osteoporosis of non-use it is the joint ends of all the bones and usually all the joints of the affected extremity. Nothing else gives this x-ray picture except, rarely, multiple myeloma.

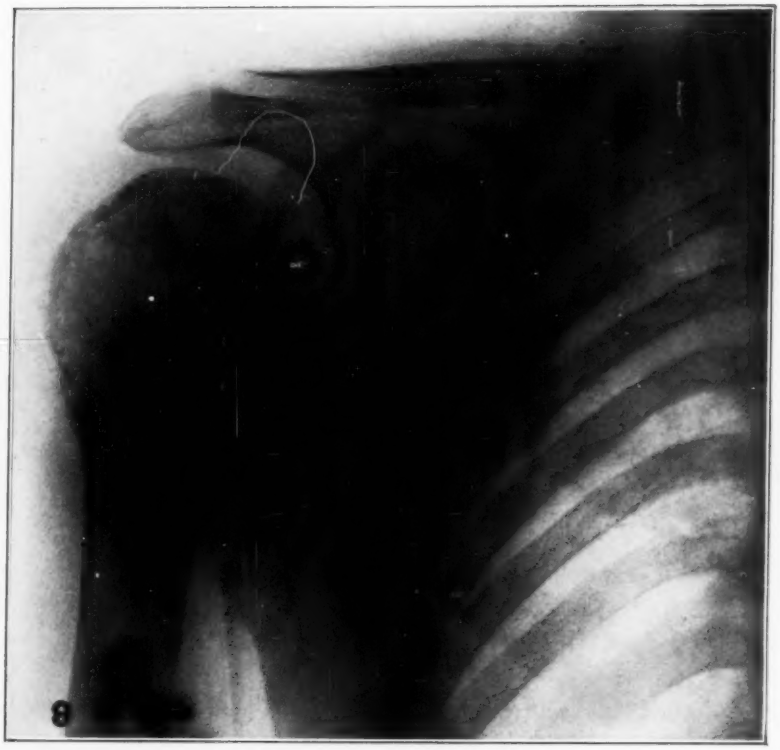

FIG. 11. (Path. No. 26721)

Central myxosarcoma upper end of humerus. Resection October 21, 1922, with bone transplant. Amputation August 21, 1923, for recurrence. Death, August 22, 1924, metastis to lungs. White male, 43. Localized pain, head of humerus 18 months. Loss of function 9 months. Swelling 3 months. Palpation bone shell very thin. X-ray shows beginning of destruction and perforation of bone shell and very little new periosteal bone formation. Diagnosis rested between giant-cell tumor and myxosarcoma. I diagnosed sarcoma from the unusual pain and bone reaction in the periosteum shown by the x-ray. But this is not correct for a subsequent similar case proved to be giant-cell tumor and the exploration and frozen section diagnosis saved the arm.

In multiple myeloma the pictures resembling osteoporosis of non-use are present only in the late stage of the disease, and diagnosis is not difficult.

Trauma and Sarcoma. We must admit that the evidence so emphatically favors a relationship between trauma and the development of a sarcoma that the majority of accident insurance and workmen's compensation commissions have accepted it.

Sarcoma and Fracture. In my studies in pathological fractures already mentioned there seems to be one verified example of a sarcoma that has developed after the ossification of a fracture and very quickly after it. But the trauma that produces a fracture rarely is followed by malignant disease. Nevertheless this case shows this possibility.

Chronic Irritation and Cancer. Trauma and Sarcoma. It is now

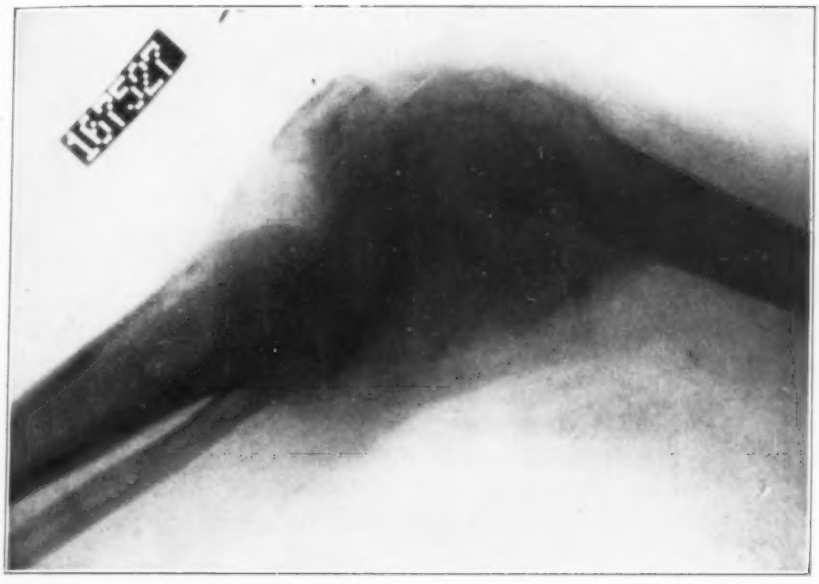

FIG. 12. (Path. No. 37360)

X-ray lateral view, recent; giant-cell tumor, lower end of femur. This case was diagnosed clinically and in the x-ray by most of my colleagues as sarcoma, yet in the gross and microscopic picture it does not differ from the numerous cases who are well after curetting only. The x-ray shows pathological fracture and the almost complete destruction of the bone shell. Patient was white, female, aged 23, and the symptom of onset was pain for 8 months followed by swelling and 7 months later by pathological fracture and inability to walk.

accepted that chronic irritation is one of the causes of cancer and that a single or repeated trauma is one of the causes of sarcoma. But there is every evidence that there is another cause or that there are other causes which as yet are undiscovered. Why has a discussion of trauma anything to do with the diagnosis and treatment of bone lesions? In my experience it has everything to do with it, because in so many of the cases there is history of trauma, and the patients later come under observation. The people are educated to have an x-ray when there is a fracture, but they are not educated as yet to the importance and protection of roentgenogram after a contusion. Such an x-ray not only clears up any possibility of a fracture, but it gives us a picture of the injured parts for comparison when the signs and symptoms of the bruise do not subside or symptoms reappear after a quiescent period.

What may happen after a trauma or a bruise to the soft parts? Simply pain or ecchymosis which disappears, a hematoma which may become infected or organized, an ossifying myositis, or an ossifying periostitis, a giant-cell tumor, a sarcoma; the localization of tuberculosis or osteomyelitis, or a fracture.

The first x-ray will picture the fracture if present. In the case already noted the x-ray visualized the development of the giant-cell tumor.

When a mass in the soft parts around the bone is felt and the x-ray shows a clear space between the bone formation and the soft parts and the normal shaft, sarcoma can be excluded. But when the bone formation begins in the periosteum and is of slight degree, sarcoma cannot be excluded. There is not much difficulty in excluding the excessive periosteal bone formation after a trauma, because, as far as my observations go, this is very unusual. What I am trying to picture is the possibility of a diagnosis if x-rays are taken at frequent intervals after a trauma, and as far as my actual facts allow deductions, we can recognize the ossifying myositis and the excessive ossifying periostitis, but we cannot differentiate a subperiosteal hematoma with ossification and a slight ossifying periostitis from sarcoma.

Routine Method of Diagnosis. In the majority of cases unless there is a fracture or there has been the history of a fracture, patients with bone lesions seek advice because of pain, a palpable swelling and loss of function. The longer the patients wait, the easier the diagnosis. When I studied my first forty-two cases of bone tumors in the days when we had no x-rays (1900), diagnosis was not very difficult, but in the past few years the enlightened public seek consultation so quickly that all types of bone lesions are seen in their incipiency, and, in some cases, even with biopsy, the exact nature of the pathological process is confusing.

There are certain definite things any doctor can do: He can record an accurate history in which the history of trauma and fracture is very important, he can palpate again and again the affected parts. The feeling of a bone shell surrounding a central tumor is entirely different from the palpation of the periosteal mass in the diffuse or periosteal lesion. Pain and tenderness are often very helpful in diagnosis. The giant-cell tumor with great destruction of the bone shell, even with pathological fracture, may be almost as painless as a Charcot joint, but this is never true in malignant disease. Anyone can take the Wassermann and make the blood count and examine the urine for Bence-Jones bodies, make a physical examination of the chest for a possible tuberculosis and go over the entire body searching for a primary tumor. After establishing the presence of a local lesion in a bone by the history and palpation, even before taking the x-ray, go all over the skeleton for other bone lesions, because multiplicity places the case in a different group. It is always wiser in taking the x-ray to include the corresponding uninvolved bone and to take the chest, and it is always safer to take two views of at least the affected part. For example, a patient was sent to me with the diagnosis of a periosteal sarcoma in the region of the right tibial tubercle. Exploration with possible amputation had been advised. No x-ray had been taken of the uninvolved left tibia. When this was taken and the two films compared, it became apparent that we were dealing with a contusion of the beak-shaped process of the tibia—the so-called Schlatter-Osgood disease.

After the first x-rays the lesion can be identified as central, periosteal or diffuse; shaft or epiphysis; single or multiple; with a negative chest, or

one with evidence of tuberculosis or metastasis. Then the laboratory reports show the result of the Wassermann reaction, the blood count, and whether or not Bence-Jones bodies are present in the urine.

CENTRAL SINGLE LESIONS OF THE SHAFT IN CHILDREN UNDER EIGHTEEN

This practically means a bone cyst. There are a few cases of central giant-cell tumors at this age. As multiple myeloma may occur at this age, and as this disease may come under observation as a single lesion, it must be considered a possibility. But I have seen only one case at this age, and then it was multiple.

Treatment. If there is a fracture through the central lesion of the shaft of this adolescent bone, or, in some instances the fracture may be above it, treat it as an ordinary fracture. Ossification of the fracture and central lesion will be complete in from three to six weeks. When ossification does not take place explore, because of the possibility of a giant-cell tumor which requires thermal and chemical cauterization after curetting.

If there is no fracture, watch the case with frequent x-rays. Improve the general condition of the child. Give sunlight and the same diet as you would for ununited fracture (calf's liver, cod liver oil, calcium lactate, milk, cream, and green vegetables). If there is bending with deformity, or expansion of the bone shell, or lack of ossification of the bone shadow, operate. Nothing is to be gained by delay. The treatment of a bone cyst is a fracture, but before producing the fracture be certain it is a bone cyst by removing a bit of the shell. Bone cysts have the following gross appearances: bone shell, fluid; bone shell, connective tissue lining, fluid; bone shell, mass of fibrous connective tissue without minute cysts, or with minute cysts (polycystic). In the thick connective tissue lining or in the solid mass there may be red areas which under the microscope resemble the giant-cell tumor. The connective tissue lining may be covered with a white snow of calcium deposit. The fluid may be clear or cloudy. The bone cyst needs neither chemical nor thermal cauterization. It insures more rapid ossification if the connective tissue within the bone shell is removed and the shell is fractured or crushed.

The giant-cell tumor, which is possible, has an entirely different gross appearance. As a rule the cavity in the bone is filled with a soft, very hemorrhagic, cheesy material, which bleeds like edematous granulation tissue, and the bone shell bleeds when it is curetted. There may be a cavity filled with blood, and this friable, red granulation tissue lines the bone shell. This tumor needs thermal and chemical cauterization after curetting.

Very rarely one will meet with a caseous tubercular mass.

When there are large cavities, bone transplantation can be employed, but this is rarely indicated in the shaft, except in the big neglected bone cysts.

FIG. 13. (Path. No. 37088)

Metastatic hypernephroma. Confirmed by microscopic sections. Clinically a single tumor with no evidence of a kidney tumor.

In these central lesions of the shaft in children, the chances of a giant-cell tumor are so small that it seems to me it is a waste of time and money to give x-ray or radium treatment. The cases so treated have not ossified any more rapidly than the larger group untreated.

CENTRAL LESIONS OF THE SHAFT IN ADULTS

The majority of these are chondroma, myxoma, metastatic tumors (Fig. 13), myeloma, and the possible chondromyxosarcoma. I have never observed a giant-cell tumor in the shaft of an adult. I have already mentioned the possibility of a latent bone cyst. If this cyst is ossified it should be recognized at once; if not, its shadow cannot be distinguished from the other possible lesions.

As to treatment, I believe one is justified in using radiation first in the central lesions of the shaft of adults, whether there is fracture or not, but if further x-rays show no ossification of the central lesion, or show further expansion, or destruction of the bone shell, operation is indicated. I should explore with the cautery and if the lesion proves not to be a bone cyst, resect and do a bone transplantation. Numerous x-rays and histories have been referred to me in which the opportunity for a possible cure has been lost by an attempt at curetting rather than resecting, or performing amputation rather than resection. Even if the tumor is a single lesion of metastatic origin, or of a multiple myeloma, resection and bone transplantation will restore function for the time the patient has to live better than any other treatment. Remember also that a fracture in any one of these lesions may temporarily unite, but ossification of the central lesion is observed only in the bone cyst. In the metastatic tumor there may be excessive ossification, but it gives an x-ray picture distinctive of itself. My records show that the central lesions of the shaft of bone in adults are

giving both the roentgenologist and the surgeon the greatest difficulties in diagnosis and treatment.

Multiple Lesions of the Shaft. In children, with the rarest exceptions, these are multiple bone cysts. Multiple myeloma is a possibility. All of my cases of multiple chondroma in children have involved shaft and epiphysis or have been associated with exostosis. The multiple shaft lesions of the adult are usually metastatic or multiple myeloma; very, very rarely bone cysts.

Central Lesions of the Epiphysis. There have been a few in children, and these have been giant-cell tumors. In the adult the majority are the giant-cell tumors, with a few scattered bone cysts, chondromas, myxomas, myxochondrosarcomas, metastatic tumors, and multiple myelomas. Rarely do these lesions come under observation with fractures. In central lesions of the epiphysis one is justified in trying radiation first, during which time the patient should be at rest in bed, in splints, or on crutches. I have recently observed ossification of the thinning bone shell in cases of this kind. What further observations may lead to, I do not know. But if the bone shell is intact and radiation produces no ossification within the shell, or if the bone shell is destroyed or thin and radiation produces no visible thickening, nothing is gained by delay. In some epiphyses resection is the operation of choice, irrespective of pathology—the lower end of the ulna, both ends of the fibula. In other epiphyses curetting with thermal and chemical cauterization gives a far better functional result than resection with bone transplantation. The public must be educated to come before the bone shell is destroyed and the roentgenologist and surgeon must be influenced to strike at once, unless radiation definitely preserves or restores the bone shell. Even then, in my opinion, precious time is lost, and the risk of poorer function is run by further radiation. If surgeons will learn the technique of curetting with proper thermal and chemical cauterization, roentgenologists cannot compete even with the best results of radiation. But when surgeons continue to have recurrences after curetting, and infection and amputation after curetting with the introduction of radium into the bone cavity, roentgenologists will get better results with radiation.

Note February 20, 1926. RADIATION FOR GIANT-CELL TUMOR. Since the above was written I have seen the x-rays of a number of cases, and the patients in a few, in which the evidence favored a giant-cell tumor of the epiphysis. In many of these cases there was evidence of bone destruction of the shell. Under radiation the destroyed areas were replaced by bone, and in all of them the bone shell seemed thickened. In one instance there has been a biopsy with the microscopic section picturing the giant-cell tumor. In not a single case was there positive evidence of complete ossification as we have all observed in the bone cyst,—whether operated upon or not, or whether there was a fracture or not. In addition to the restoration of destroyed areas and thickening of the bone shell in these cases, there has been some shrinkage in some; in none has there been further expansion. Pain has been relieved and function restored.

How these results will compare with curetting, with or without bone transplantation at the end of five years, remains to be seen. But my experience with curetting

properly performed is that the results are uniformly perfect. If radiation accomplishes the same results, it will be simply a choice between operation and radiation.

In two cases of central giant-cell tumor of the lower jaw given thorough radiation for more than one year nothing was accomplished, except a slight thickening of the bone shell and prevention of further expansion. When I removed the tumors by curetting there was no evidence of ossification of tumor tissue, and, under the microscope, no difference in the picture. In a giant-cell tumor of the upper epiphysis of the humerus incompletely curetted, intense radiation after operation did not prevent recurrence with complete destruction of the bone shell. So the patient had to have resection with bone transplantation.

CONCLUSIONS AND SUMMARY—CENTRAL BONE LESIONS

The first point to emphasize is:—Sarcoma as a central bone lesion is rare and up to the present time it is a question as to a positive five-year cure after an amputation. In Codman's registered cases of five-year cures, accepted by the committee, there are no examples of central sarcoma. The number of central sarcomas recorded in my contribution in the Journal of Radiology for March 1920, has been reduced by further study, and the two cases recorded there as five-year cures were not accepted by the committee. One of these (Figs. 23, 24, page 218, Journal of Radiology, March, 1920) I withdrew myself on further study, with the revised diagnosis of a latent bone cyst in the lower end of the femur. A second, still living more than ten years after amputation, was a typical gross example of the so-called bone aneurysm, an intact bone shell, a cavity filled with blood, with here and there more or less tumor tissue attached to the bone shell. In this case the sections did not contain the predominating and typical giant-cells of the foreign body or epulis type. Ewing and Codman viewed this registered case of mine as a variant of the giant-cell tumors, others agreed with me in the diagnosis of sarcoma. In Codman's series, and in my own, this case, Heine (Pathological Number 14229, Figs. 20, 21, in the Journal of Radiology, March 1920), is unique. In that paper I also recorded another bone aneurysm in the lower end of the femur (Figs. 11, 12) as a possible sarcoma. The Committee was about divided on the diagnosis and we now practically agree that it should be called a benign giant-cell tumor. This short statement gives but a bird's eye view of the years during which this giant-cell tumor has been recorded and treated as a sarcoma, and has given surgeons encouragement to sacrifice a limb in order to save a life, and today there are surgeons and pathologists who seem unable or unwilling to look upon this giant-cell tumor as a benign pathological process.

I early found in my studies that, among the patients living five years after amputation, there were a few central lesions diagnosed chondrosarcomas. On restudy of the tissue the histological picture was that of a chondroma. I have found in many clinics that these chondromas which present cellular areas are still called sarcomas. This group with the giant-cell tumors compose a large number of the cases registered with Codman as five-year cures after amputation.

In my list there is still one apparent bone aneurysm which must be looked upon as malignant. It was situated in the lower epiphysis of the tibia; the bone shell was intact; when first operated upon and curetted the bone cavity contained blood and a little tumor tissue, friable and hemorrhagic, resembling giant-cell tumor, but in the sections there were no giant-cells but a tumor tissue called then small round-celled sarcoma. This tumor recurred and the patient died a few months after amputation from metastasis to the lungs.

Sarcomas which have evidently arisen in pre-existing chondromas or myxomas are the only proven types of central sarcoma in which the bone shell is intact. In my cases none has survived five years after operation.

The pure myxomas may arise as central lesions just as chondromas. When these myxomas have involved bones other than the phalanges, metatarsal or metacarpal, they have been explored, removed piece-meal, recurred, then the patients have submitted to amputation and finally died of metastasis.

My second point is the natural conclusion from the statement of the first point: Central sarcoma with intact bone shell is rare, and so far, with the possible exception of my one case, there have been no five-year cures, therefore when the x-ray shows a positive central lesion there is no danger of delay.

There is no objection to trying radiation first, unless the age and the involvement of the shaft indicate a bone cyst. In this lesion diet is more important than radiation.

Our greatest responsibility is: not to make diagnosis of malignancy in benign bone cysts or advise the unnecessary expense of x-ray treatment; next, not to allow a benign giant-cell tumor of the epiphysis to proceed to the thinning and destruction of the bone shell because in this event curetting, although it may accomplish a cure with bone transplantation, will not preserve the same good function.

Our next ambitious endeavor should be to recognize the possible and fortunately infrequent central chondrosarcoma or myxosarcoma, or the pure myxoma, so that we may explore under the protection of the cautery, recognize from the gross or frozen section, and radically remove by resection or amputation.

In some instances it may be possible to diagnose without exploratory incision and so resect or amputate this malignant group. Then again we must learn to pick out the benign chondromas and not submit these cases to mutilating operations. The chief danger of exploring chondroma is the transplantation of bits of tumor cartilage into the soft parts. These bits of tissue grow to new tumors.

I have sufficient evidence to indicate that something can be done for the comfort of patients with metastatic bone tumors and the temporary restoration of function by properly selected cases of resection and bone transplantation.

For the multiple myeloma, I have no data which offer any hope.

The so-called Brodie's abscess in the epiphysis or shaft, without the characteristic clinical picture of osteomyelitis and without an x-ray shadow with indication of periosteal bone formation, is very infrequent. These cases will resist x-ray and when explored the pus or granulation tissue in the bone cavity will distinguish it from other central lesions.

There is one other x-ray picture that should be mentioned here, but it will require a second paper to fully discuss it. Diffuse sarcoma of the osteoporosis or destructive type may have so little periosteal tissue and so little periosteal bone formation, that one can palpate nothing abnormal and can see in the x-ray only the localized zone of somewhat honeycombed or diffuse absorption. In all of my experience I have only four such x-rays, as this type of sarcoma is rarely cured, if ever, by amputation and often reacts favorably if only temporarily to radiation. There is no objection to the rule already given, to try x-ray first. This x-ray is usually associated with Ewing's type of tumor (a round-celled sarcoma or angio-endothelioma.)

THE OPERATIVE TREATMENT OF CONGENITAL TORTICOLLIS: ADVANTAGES OF EXSECTION OF THE TWO HEADS OF THE STERNOCLEIDOMASTOID*

BY DAVID SILVER, M.D., PITTSBURGH, PA.

A number of operative procedures have been advocated for the relief of congenital torticollis, with all of which insistence is laid on the importance of fixation of the head in the over-corrected position, and from time to time a new appliance for maintaining this position is presented. It seems not out of place, therefore, to describe two simple modifications of the customary procedure which apparently afford additional insurance against relapse, greatly simplify the after-treatment, and render a retentive appliance unnecessary.

The usual short transverse incision through the skin is made a little below the middle of the clavicle and midway between the two heads of the muscle. The skin being retracted upward and inward, the fascia and the sheath of the inner head are split vertically sufficiently to permit a grooved director to be passed under the inner head, which is then clamped with a hemostat. The inner head is now divided on the director as close to its insertion to the sternum as possible. Its proximal end is next drawn out through the incision and a half to three-quarters of an inch cut off. In a similar manner the same amount is exsected from the outer head. The deformity is then over-corrected and any tight fascial bands picked up and divided on the grooved director. The fascia is closed with fine catgut and the skin with waxed silk.

All the blood is now carefully expressed and further hemorrhage and effusion prevented by means of a compression dressing. The adhesive strips for maintaining the pressure are carried from low down on the opposite side of the back diagonally upward over the dressing and then diagonally downward toward the opposite side of the lower chest. This compression dressing is continued until healing is complete.

The wider separation of the two heads from their attachments brought about by the exsection and the prevention of hemorrhage and effusion in the sheaths due to the use of the compression dressing insure a longer and a relatively much weaker cicatrix between the cut ends. Hence it is assumed that there is a probability of stretching under early functional use and less likelihood of relapse from later cicatricial contraction.

In our earlier cases a Thomas collar was applied to maintain moderate over-correction, but in recent years no retentive appliance of any sort has been employed. The patient is allowed to hold the head as desired

*From the Orthopaedic Clinic of the Allegheny General Hospital.

during the early days of convalescence. As soon as the incision is sufficiently healed, the usual active corrective exercise is begun (chin carried toward shoulder of affected side and head flexed toward opposite shoulder). At first, naturally, the movements are somewhat guarded, but the full range is soon restored, and finally the patient is urged to use all the force possible. The exercise is persisted in until muscle balance is restored. If the accompanying scoliosis proves resistant, corrective exercises for this are added.

This method of treatment has been in use in our clinic for the last eight or ten years and has proven successful in all cases thus far encountered. The oldest patient operated upon, one of average severity, was seventeen years old.

A BONE GRAFT FOR SACRO-ILIAC FIXATION*

BY P. JENNER VERRALL, F.R.C.S., LONDON

Many methods have been devised for fixation of the sacro-iliac joint. Most of these aim at obtaining bony ankylosis of the joint itself, in part, at any rate. In the case of tubercle during any such proceeding it is obvious that diseased bone must be exposed or an abscess opened. Complete resection of the joint is a most formidable operation, and the operations for fixation by a countersunk block, or by a sliding graft from the ilium, though frequently effective are certainly prolonged and elaborate.

At the Royal Society of Medicine a case was shown of a man with unilateral sacro-iliac arthritis, probably tuberculous, for whom in 1923 I had used the method of bone grafting explained in this paper. In December 1924, another case was shown at the Royal Society of Medicine, an officer for whom I had done the same operation for chronic pain and instability of the joint following a fall from a horse. Since then I have performed the operation twice, once for known tuberculous disease. The result in the first case was that the man was completely relieved of pain and other symptoms, and the skiagraph taken six months later showed diminishing arthritis and repair in the joint. In the second case, in spite of several years previous disability, the patient was able to engage in full athletic pursuits six months after the operation. Of the other cases, final results cannot yet be given, but their progress to date has been satisfactory.

The weight of the body transmitted down the spine reaches the sacro-iliac joints both as a force directed downwards and outwards, and also as a shearing strain, the wedge-shaped sacrum being driven down between the two ilia.

As in an old house, where the weight of the roof is tending to force the walls outwards, an iron tie rod with cruciform nuts at each end is often inserted; so it appeared that the sacro-iliac joints might be supported by a similar method, employing a tibial bone-graft.

The position of the patient and the general technique are the same as for an Albee spinal graft. A semilunar incision is made, convex upwards, commencing two inches below and external to one posterior superior iliac spine, and passing thence upwards and across the middle line to the corresponding point on the opposite side, thus enabling a skin flap to be turned down exposing both processes and the intervening parts covered with the lumbar fascia. With knife and periosteal elevator both posterior superior iliac spines are cleared from muscle externally and internally. A vertical incision, three inches in length, is now made over the sacral spines,

*Read at the meeting of the British Orthopaedic Association, Manchester, England, October 1925.

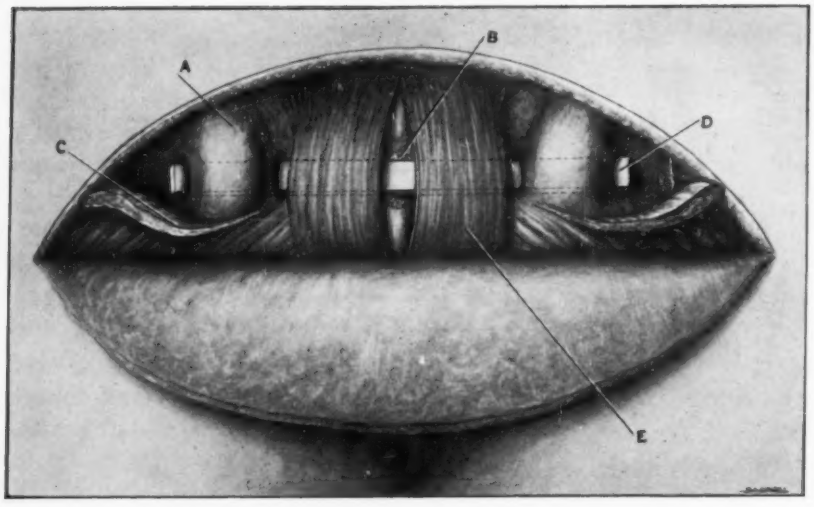

FIG. 1

A. Posterior Superior Iliac Spine. B. Sacral Spine (removed).
C. Gluteus Maximus. D. Graft. E. Erector Spinae mass.

in the mid-line between these two points. The sacral spines are cleared with an elevator and it will then be found that the second sacral spine lies directly in a line between the two posterior superior spines. This spine is removed. The bone is very thin and the spinal canal may be opened, but this is not a serious accident.

With a large gimlet-drill, followed by a narrow gouge, a tunnel is cut through the two exposed iliac spines from without inwards, sufficient in caliber to hold a tibial graft three-eighths to one-half inch wide. The bone is quite cancellous and no force is needed in boring.

Next, with a large blunt periosteal elevator the erector spinae muscle masses are raised from the sacrum along the line of the proposed graft.

With a long probe measurement is taken of the length of graft required to pass through one tunnel, under the muscle, across the raw surface left by the removal of the sacral spine, and on to the other side. A three-eighths to one-half inch wide graft of the requisite length is cut from the tibia in the usual way, and this is driven in from one side with light blows of the hammer until it emerges through the opposite tunnel, the medullary side of the graft facing downwards so as to be on the raw area on the sacrum. No fixation is required, the fascia is closed with catgut and the skin closed. The graft here bears a tension strain as does an Albee graft, and also a bending strain, when union with the sacrum occurs.

My first two cases were treated on plaster beds, the first for five months, the second for three. In the tuberculous case recently a spinal frame was used and in the most recent no splint at all. Obviously this part of the treatment depends on the condition for which the operation is performed. In cases of mild arthritis or instability, two months' recumbency,

followed by the wearing of a carefully fitted sacro-iliac corset for six months, will suffice. In tubercle, obviously, the graft serves the same purpose as an Albee spinal graft in diminishing the period of external fixation required.

Patients with merely chronic painful instability or mild arthritis of the joint will obviously be loath to submit to such drastic treatment, but, in my opinion, it is well worth while when the wearing of a belt is insufficient.

The advantages of this method are:

1. That the tie beam is the true sacro-iliac support.
2. The operation is easy and no extra fixation is required.
3. It is extra articular, and there is at least good hope of avoiding an abscess in tuberculous cases.
4. Results have been good in the limited number of cases as yet treated by this method. Two of my colleagues have each performed the operation once and have been kind enough to tell me of their results.

If any other surgeon should try this method, I should much appreciate the courtesy of a note on the progress of the case.

REFERENCES

VERRALL, P. JENNER: Lumbo-Sacral Backache, Brit. M. J., Nov. 1, 1924.
Diagnosis and Treatment of Affections of the Sacro-Iliac Joints (Opening Paper). Proc. Roy. Soc. Med., April, 1925.

OPERATIVE TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR WITH MAXIMUM FIXATION

BY WM. O'NEILL SHERMAN, M.D., FITTSBURGH, PA.

The treatment of simple fractures of the shaft of the femur has been one of the most difficult problems with which the surgeon has had to contend. The great diversity of opinions and methods of treatment are most confusing to those anxious to ascertain the real merits of the various procedures. The controversy over the open or closed method, has continued unabated for the past thirty-five years, and bids fair to continue for many more years judging from the present attitude of those who refuse to recognize or consider the limitations of both methods. Each when properly used, undoubtedly, has distinctive merit, but neither can be used routinely to the exclusion of the other. It seems hardly necessary to repeat what has been said so often, that no fracture should ever be operated on if a reasonable anatomic restitution can be secured which will give a functional result permitting the patient to resume his former employment without disability. Certain surgeons are satisfied with an end functional result of sixty-five to eighty per cent. normal, feeling this is the best possible result obtainable. This impression is due largely, no doubt, to the methods used in the treatment of many of these cases. A survey of the end results reveals a great many permanent disabilities which, if properly treated, could have been averted.

OBJECTIONS TO THE OPEN METHOD

The great criticism to the open method of treatment has been that infection, with its many disastrous consequences, is often encountered. In the writer's series of more than fifteen hundred open operations for the reduction of fracture during the past seventeen years, the percentage of infection is no greater than that in the ordinary elective operation, such as inguinal hernia, for example. If infection occurs following operation, it is due usually to the faulty technique of the operator, i.e., lack of scrupulous asepsis, and to disrespect for tissue, such as traumatism and excessive manipulation, resulting in its devitalization. Sterilized steel plates and tap screws of themselves do not cause infection or osteomyelitis, but the surgeon who contaminates such materials by skin contact and faulty technique, does.

In short, the usual technique employed in laparotomies, etc., is not sufficiently refined for open bone operations. The most scrupulous, aseptic technique is necessary if infection is to be avoided. Unfortunately, few surgeons have been sufficiently interested in this operation and technique to organize operative teams along the lines absolutely necessary if success

is to be secured. One rarely finds this very rigid technique in practice except in a few clinics where open operation has been given special thought and attention. The surgeon who operates rarely in such cases finds it rather awkward and difficult to carry out such technique in detail, and as a result, he is prone to blame the plates, screws, catgut, or operating room nurse, when infection occurs. Seldom does he look to himself or consider himself a causative factor.

It is quite true that the operative method involves a greater risk, but the end functional results when compared to those obtained by non-operative methods are so far superior that the additional risk in competent hands is perfectly justifiable. The injured are entitled to ninety-five to one-hundred per cent. return of function and anything else should be considered an unsatisfactory result.

The prolonged disability frequently resulting from fracture of the femur is apparent to anyone who has made any investigation or inquiry as to the end functional results. To visualize the great army of cripples as a result of this fracture makes one shudder.

Those who decry and condemn the use of steel plates, screws, etc., have had very little practical experience or knowledge of the results secured by this operation. The majority of the permanent disabilities could have been prevented had proper operative procedure been resorted to at an early date. Delay beyond twelve to fourteen days frequently results in failure of operative measures, as well as greatly retarding early bone union with a minimum of callus.

OPERATIVE TECHNIQUE

The technique recommended to be followed in the open reduction of fracture of the femur or any long bone is:

The patient is given a general bath the day preceding operation but no special skin preparation is necessary.

In the operating room, the area is painted with a five per cent. alcoholic solution of picric acid, and then carefully draped, the towels being so arranged as to prevent exposure of any part. At no time are the gloved hands, instruments, sponges, etc., permitted to come in contact with the skin.

A free and ample lateral incision is made through the skin and subcutaneous tissue. The scalpel and tissue forceps used in making the skin incision are considered as infected instruments and are discarded.

The skin edges are then undercut to permit of the fixation of Turkish towels along the line of incision in such a manner that the skin wounds are completely and thoroughly blocked. A Moynihan or Lane towel forcep or Michel clips can be used for this purpose. The towels at the ends of the wound are held by a Bacchus towel clamp. It is extremely important that the skin be protected absolutely by the towels as exposure would tend to contaminate the instruments, catgut, plates, etc.

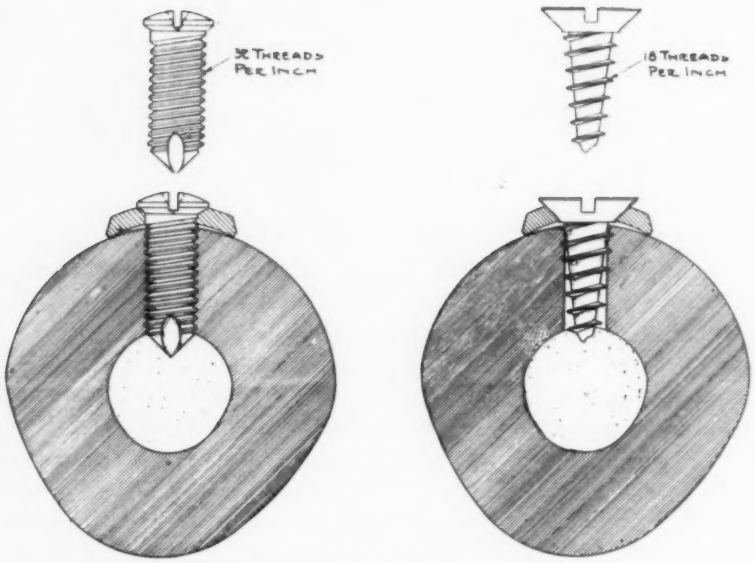

FIG. 1

Cross section showing relative purchase of author's vanadium steel tap screw, and wood or carpenter screw. Wood screw is contra-indicated in bone-plating operations. One machine tap screw has four times the purchase of four wood screws.

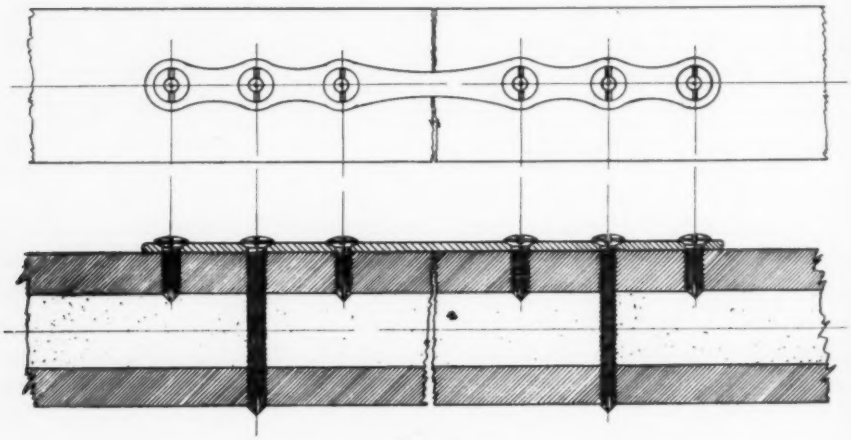

FIG. 2

Maximum fixation with minimum foreign material. Vanadium (author's design) steel plate with transfixion of bone, giving maximum fixation and security.

The fascia lata and the soft parts directly overlying the fracture are incised by sharp dissection. The fractured ends are exposed and clamped by a Lane or Lambotte bone forcep, are gently curetted and any intervening tissue removed. By combined extension and manipulation the fracture is reduced and a hairline anatomic restitution is usually obtained. A large Lambotte clamp is fastened on the femur at the site of fracture to hold the reduction thus obtained.

A vanadium steel plate (author's design) is then applied and affixed to the bone by two or four transfixion screws in such a manner as to prevent displacement. The holes in the bone that take the screws are drilled through the proximal and distal holes of the plate and through the cortex of the bone with a No. 32 Brown-Sharp drill, hand or motor driven. It is well to hold the plate in the place it is to occupy by means of light Lambotte clamps while the holes are being drilled for should the plate become slightly displaced after the drilling is started, it is very difficult to engage the screws in the drilled holes. The shaft of the femur is measured with calipers in order to determine exactly its diameter and screws applied of such a length that they will just transfix the distal cortex without projecting beyond the surface into the soft parts. Following the fixation of the proximal and distal ends of the plate, the clamps holding the bone-plate to the bone may be removed and the remaining holes drilled and screws inserted, but the clamp holding the fracture *in situ* should not be removed until all of the screws have been inserted.

A careful inspection of the wound is made, the soft parts are closed with figure-of-eight catgut sutures, the bleeding points are ligated and the fascia lata closed with a continuous suture of catgut. Complete hemostasis should be secured—drainage is never used. The skin incision is closed with Michel clips.

It is not necessary, providing one is equipped with the proper armamentarium, to introduce gloved fingers into the wound. All sponging, manipulation, and suturing is done with instruments. The operating nurse handles all materials with instruments. As the sponges become soiled, they are discarded and replaced with fresh ones.

It is very important that all of the above refinements be carried out in detail and failure to do so is simply inviting infection and disaster. After each instrument is used and soiled, it is washed in a .5% solution of sodium hypochlorite, and then rinsed in water. The sodium hypochlorite is strongly antiseptic and haemolytic rapidly dissolving the blood stains from the instruments and permitting thereby the replacement of instruments free from blood on the table. At the conclusion of the operation, the instrument tables should be unsoiled, and the operating field other than the towels surrounding it, should be free from blood stains. Never should the gloved hands be introduced into the wound.

The technique for the open reduction of fractures requires intensive training on the part of the operator and his assistants, including the operating room nurse, but when once organized and understood, it can be done readily and easily without undue effort or confusion.

FOSTOPERATIVE TREATMENT

Immediately following the operation, the leg is placed in a Thomas splint, flexed by the use of Pierson attachment, and then swung from a Balkan frame. Plaster is never used.

The Michel clips are removed on the fourth day, and passive movements of the knee joint begun on the third or fourth day and continued daily. With immobilization of the fracture by transfixion screws, active and passive motion can be freely indulged in without any danger whatsoever of disturbing the position.

At the end of seven and one-half to eight and one-half weeks after operation, the patient is fitted with a walking Thomas caliper. Active motion physiotherapy and electrotherapy are given daily, or every other day. The calipers are worn for two and one-half to three months after operation.

Patients so treated often return to light work in from four to five months and resume their former occupations in six months. Early mobilization is a most valuable adjunct in the postoperative treatment and should be instituted within the first few days. Great care should be taken not to permit weight-bearing until the union is firm and the callus hard.

TRACTION

Skin traction, except in the occasional case, is of little value and seldom can be used successfully. Skeletal traction (tongs or Steinman pin —tongs preferred) is the method of choice in the reduction of fractures by the closed methods. *Mere correction of over-riding or shortening is insufficient. The normal weight-bearing axis should be obtained and at least twenty-five per cent. of the fractured fragments should be in contact,—mere corner apposition is not sufficient.* Skeletal traction has its limitations of usefulness and is not a panacea. If reasonable assurance can be given that skeletal traction will correct the deformity as well as restore the normal axis, then it should be used. Falling short of this, open reduction is indicated. Skeletal traction as used in the war in the treatment of compound, comminuted fractures, where extensive debridement had been performed, is quite a different problem from the application in simple fractures in well-muscled individuals.

Ashhurst and Crosson (Archives of Surgery, Vol. XII, pages 453–493, Feb. 1926) in a report of 111 fractures of the femur during the past ten years, report sixteen fractures of the shaft in which thirty-one per cent. were subjected to open reduction. Traction evidently failed to correct the malposition, otherwise, operative measures would not have been used.

Hitzrot (Annals of Surgery, Vol. LXXXIII, page 302, 1926), was not favorably impressed with the end functional results in a survey of ninety-six cases of fracture of the shaft of the femur treated by skeletal traction in the metropolitan hospitals of New York. In but four of the ninety-six cases could the end functional results be considered satisfactory, and in fifty per cent. of the cases so treated the permanent disabilities were fifty per cent. or greater.

This review of end functional results is rather startling and is quite contrary to the general impression of the results of shaft fractures treated

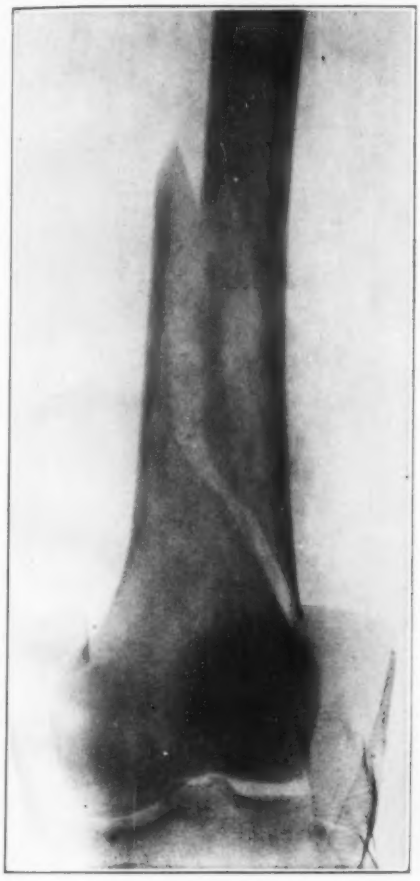

FIG. 3

FIG. 4

Spiral fracture of lower third. Perfect reduction with four transfixation screws. Fixation by transfixion screws gives greater security than encircling and constricting bands.

by skeletal traction. It is quite evident that there is a great divergence of opinion as to what satisfactory end function is.

Hitzrot has used plates and screws in approximately one hundred cases, with one death, and two infections which necessitated the removal of the plates. All three were improperly selected cases and he would not now attempt operation on similar types. In the remainder, there were no non-unions, no stiff knees, no plates removed, and, except for muscle atrophy in the line of scar, no appreciable changes in function or anatomy occurred. In other words, there were no disabilities and th[illegible]jured were able to resume their former occupations.

The end functional results in the operative cases in the Hitzrot series are certainly vastly superior to those treated by skeletal traction. The author is in entire accord with Hitzrot as to the value of open reduction

FIG. 5

FIG. 6

Maximum fixation with minimum foreign body. Transfixion screw should not extend beyond distal cortex.

as well as to its limitations. One must elect between skeletal traction and open reduction. *Open reduction is contra-indicated except where the proper armamentarium and operative technique are available.*

If skeletal traction is to be used, full reliance must be placed on it, as open reduction in the presence of caliper wounds in which there is usually a low-grade infection present, would be a dangerous procedure, and almost certain to invite infection in the operative wound. Should it be found necessary to perform an open reduction after failure of skeletal traction, in the presence of an open wound, it would be advisable to leave the operative wounds wide open, instituting the Carrel method of wound sterilization immediately following the operation. The plates and screws should be removed at the end of four and one-half to five weeks and the wound allowed to cicatrize, the Carrel treatment being continued until it does.

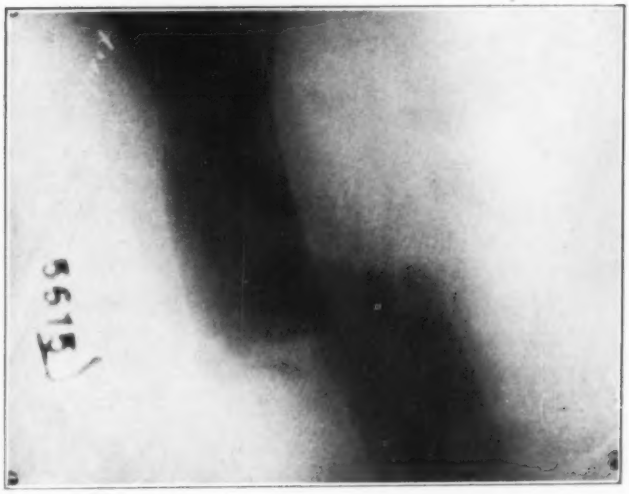

FIG. 7

Two attempts by traction (skin) and manipulation with failure.

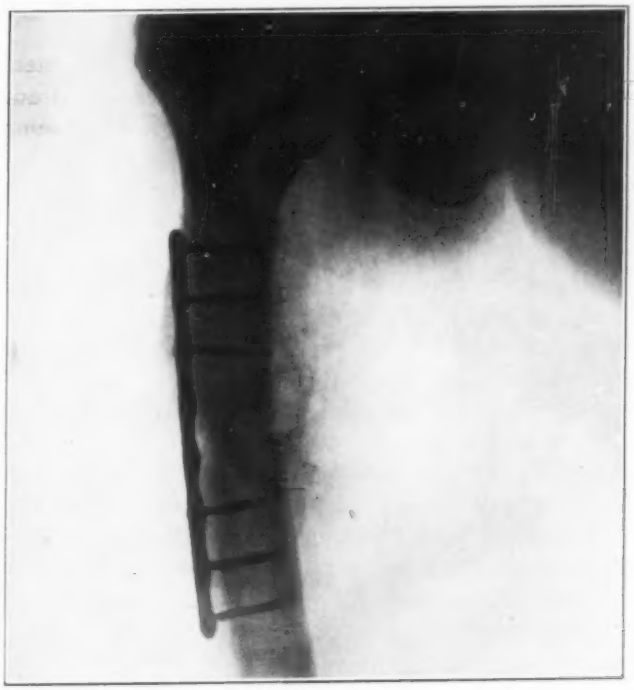

FIG. 8

Six transfixion (tap screws) with heavy plate necessary because of size of femur and difficulty of securing absolute fixation. Patient able to return to work as steel roller with perfect function in five months.

The author has had angulation occur after removal of the calipers and while the thigh was still encased in plaster.

Skeletal traction, undoubtedly, is the method of choice in the majority of cases, but it must be remembered that daily inspection is necessary and that calipers should only be used by those having experience and knowledge as to their use.

INFECTION

Should the operative wound become infected, it should be opened early in its entirety, the Carrel tubes inserted and the wound injected according to the Carrel technique, with a five-tenths per cent. sodium hypochlorite and hypertonic saline solution. With this treatment the wound infection is soon under control and within a few days the temperature and pulse return to normal. The Carrel treatment is continued and the plates and screws removed at the end of four to four and one-half weeks, the wound being allowed to cicatrize. One case of infection so treated resulted in firm union in ten weeks, with closure of the wound in six weeks; the end result was a perfect functional one, the injured returning to his former occupation as a miner.

ANATOMIC RESTITUTION

Function has frequently been expressed in terms of shortening. It is admitted that excellent function does occur occasionally in adults where overlapping is present, but this is not the rule. Mere corner approximation is not sufficient reduction to guarantee a good functional result.

To correct the normal weight-bearing axis, and to insure a good anatomic reduction, the open operation should be done at an early date, i.e., ten or twelve days following trauma.

All shaft fractures in which overlapping is present, or in which less than twenty-five per cent. end to end approximation of the fractured surface is secured, should be operated on, providing one has the necessary operating skill and armamentarium. If such facilities are not available, then skeletal traction should be used and the patient fully advised as to the possibilities of a questionable end result.

It is doubtful, as a rule, whether operative procedure is advisable in patients over sixty years of age. We have, however, frequently observed rapid union in patients between fifty-five and sixty years of age, who were considered poor operative risks, and who showed vicious displacement and over-riding of the fragments, which, if uncorrected, would have resulted in permanent disabilities.

In the heavy-muscled individual where over-riding exists, it is extremely difficult to secure a satisfactory correction by methods other than the open operation. The intervention of soft parts not infrequently impedes anatomic reposition.

The use of autogenous or heterogenous bone grafts is not warranted. The heterogenous beef bone splints are too brittle and often remain as

foreign bodies. The autogenous graft complicates the technical difficulties of this operation and increases unnecessarily the operative mortality.

Encircling bands and wires are not to be used except in certain complicated, comminuted cases; but, if they are, they should be removed after union has taken place. Such constricting wires and bands are physiologically and mechanically inferior to transfixion screws when properly applied.

END FUNCTIONAL RESULTS

The technique herein described, with minor changes, has been constantly practiced for the past seventeen years by the writer and his associates.

In a series of seventy-eight cases, there has been but one death, no amputations, no cases of non-union, and but two cases in which it was necessary to remove the plates and screws on account of infection, and in both of these cases there were excellent end functional results. The death was due to an embolus the second day following operation.

In this large series of cases, all of the injured have returned to their former positions without disability. Not one case ever claimed disability and no compensation was paid as a result of loss of function other than one in which the mere presence of a plate was construed as interfering with function, notwithstanding the fact that this patient had excellent use of his leg, walked without a limp, had good knee flexion and had returned to his former position as laborer.

The end functional results of the author's cases treated by the open method are certainly far superior to those treated by skin and skeletal traction. Extraordinary skill and dexterity are not necessary to perform this operation. A skilful surgeon of experience should be able to carry out in detail the technique required, but it is necessary that he equip himself and associates with the necessary armamentarium and technique. The operation should never be attempted until these have been attained, and it is the duty of surgeons to so equip themselves before attempting the procedure.

CHRONIC OSTEITIS OF THE SEMILUNAR BONE (KIENBÖCH'S DISEASE)*

BY MELVIN S. HENDERSON, M.D., ROCHESTER, MINNESOTA
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A chronic, slowly progressive type of osteitis of the semilunar bone, causing pain and disability, is a clinical entity, not generally recognized (Fig. 1). The objective findings are often so slight that a suspicion of malingering may well be entertained. Goldsmith in a recent, concise and clear contribution on this subject credits Speed with applying the name of Kienböch to the syndrome, which is characterized by disability of the wrist, sometimes sufficient to bar the patient from any employment necessitating its appreciable use. The pain is described as aching and annoying, and quite severe with excessive use of the wrist. There is tenderness over the semilunar bone and usually slight swelling. If the condition is well advanced and destruction considerable, clenching of the hand will show a lack of prominence of the head of the third metatarsal, which is clearly relegated to a posterior position. In advanced cases the roentgen-ray findings are typical of osteitis with fragmentation and absorption of the bone. There is usually a history of injury, but if not it is usually surmised that repeated trauma incidental to occupation is the etiologic factor. With a history of injury there is usually a history of a severe pain at the time of the accident. This soon subsides and is followed by a period of several weeks or months of freedom from both pain and disability. Discomfort gradually sets in with slight swelling, tenderness, and moderate restriction of motion. Roentgenograms made immediately after the injury are negative, but later they show varying degrees of osteitis. Speed describes the lesion as a fracture in which the fragments have been absorbed. In the typical case, there is no fracture, but unless a skiagram was made at the time of the accident, its absence cannot be definitely determined.

Of various theories with regard to the etiology, the one advanced by Kienböch is most in favor, that of subluxation, either partial or complete, with spontaneous reduction causing destruction of the blood supply, and followed by nutritional disturbances which are gradually manifested by disintegration and fragmentation of the bone. According to Müller, there are three types of lesions: anatomic, the result of pressure from associated anomalies; occupational, the result of repeated minor injuries; and traumatic. The syndrome, in typical cases, is characterized by three stages: (1) the acute, lasting possibly only a few hours, coming on immediately after the injury, rarely lasting more than a few days, and generally not more than a few weeks; (2) the period of freedom from pain and disability

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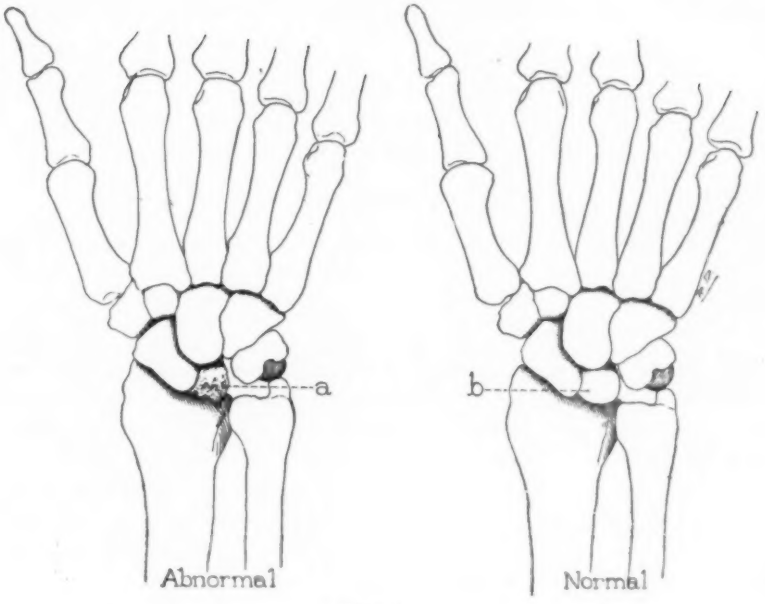

FIG. 1

a. Chronic osteitis of semilunar bone. *b*. Normal semilunar.

sometimes lasting as long as two months; and (3) the period of the actual disease in which the osteitis definitely assumes form and persists with symptoms perhaps for years. The nearest analogy to this lesion is the destructive process occasionally seen in a vertebra following an injury to the spine, known as Kümmell's disease.

REPORTS OF CASES

CASE 1. A man, aged twenty-six, came to the clinic July 22, 1925, complaining of pain on the dorsum of the right wrist and of a troublesome swelling of the right hand which prevented him from following his occupation of a telephone lineman. In May, 1924, his wrist had been forced back into dorsiflexion while he was helping to lift a telephone pole. The pain had been severe for an hour, but soon subsided, and he worked steadily for two weeks. Discomfort gradually set in and it was more or less constant and annoying up to the time of his examination, although no change had been noted for several months. Both conservative and radical measures had been advised at his home with regard to the removal of the semilunar bone.

There was slight fullness of the wrist ventrally and dorsally and definite tenderness over the semilunar bone, and slight limitation of motion in dorsal flexion. Roentgenograms showed moderate destruction, fragmentation, and absorption taking place in the semilunar bone. Removal of the bone was advised against, and splintage recommended. A prognosis was given of probably continued discomfort for several years.

CASE 2. A man, aged thirty-three, came to the clinic September 14, 1925, complaining of pain in the right wrist. He was a foreigner and could not speak English well so we did not obtain a history of definite injury to the wrist. Ten months before examination he had started to work in steel mills, and pain and swelling in the right wrist developed. The disability had increased so that he was unable to work; he even

had trouble grasping his shoes firmly enough to pull them on. There was slight swelling of the wrist, slight limitation of motion, and definite tenderness dorsally over the semilunar bone. Roentgenograms showed definite shrinkage of the bone with fragmentation. The use of a splint was advised.

BIBLIOGRAPHY

1. Goldsmith, Ralph: Kienböch's Disease of the Semilunar Bone. Ann. Surg., LXXXI, 857–862, 1925.
2. Kienböch, Robert: Über traumatische Malazie des Mondbeins und ihre Folgezustände: Entartungsformen und Kompressionsfrakturen. Fortschr. a. d. Geb. d. Röntgenstrahlen, XVI, 77–103, 1910–1911.
3. Müller, Walther: Ueber die Erweichung und Verdichtung des Os lunatum, eine typische Erkrankung des Handgelenks. Beitr. z. klin. Chir., CXIX, 664–682, 1920.
4. Speed, Kellogg: A Textbook of Fractures and Dislocations, with Special Reference to their Pathology, Diagnosis and Treatment. Philadelphia, Lea and Febiger, 1916, 896 pp.

TWO UNUSUAL CONDITIONS PRESENTING AN OBSTACLE TO THE REDUCTION FOUND BY OPEN OPERATION FOR CONGENITAL DISLOCATION OF THE HIP

BY Z. B. ADAMS, M.D., BOSTON, MASSACHUSETTS

An experience with congenital dislocation of the hip leads me to believe that occasionally there is a soft tissue barrier which prevents the femoral head from sinking deep into its place in the acetabulum.

This case of double congenital dislocation of the hip in a child of three years was reduced by Denucé's method, the heads both entering the sockets with slight shock; but there was a marked jump when the heads went out as the legs were brought down to straight and slight jump as the knee was brought forward.

Hips were held in ninety-ninety degrees position for six months. At the end of four months these plasters were cut off just above the knees and the child started to limber knees by exercise in flexion and extension. Slight rotary motion was also given.

At six months the whole of plaster was taken off and exercises started to develop the gluteal muscles, rotators and adductors.

After four months there was good range of motion in flexion, rotation, and hyperextension, but practically no gain in the ability to bring the knees together and the heads were felt plainly in front. X-ray showed the heads in front of and below the sockets.

By manipulation under ether left hip could be put back in the socket and the thigh could then be adducted only to forty-five degrees. The right hip could not be put in the socket and could not be adducted. X-ray showed the right head in obturator foramen, the left head in its socket but not deep in the socket, and it slipped out easily.

Open operation was done. The right hip had a strong transverse band in the front of the capsule (a fold of the capsule ?) which was cut through before the head could be put in the socket, the incision being made in the longitudinal axis of the neck in the region of the upper edge of the iliofemoral Y-ligament. The tendon of the recuts was also tenotomized and then the head went into the socket with ease and stayed there when the thigh was brought to thirty-five degrees position and kept inwardly rotated.

The left hip was also opened. Here the bands were found deep in the socket at the back, possibly a thickened cotyloid ligament folded in before the head, at the first reduction. This band being cut and the tendon of the rectus tenotomized, the leg could be put in the thirty-five degrees position and in inward rotation. The head was secure in the socket.

Now, three months later, the x-rays show both heads deep in the sockets.

FRACTURES OF THE SURGICAL NECK AND EPIPHYSEAL SEPARATIONS OF UPPER END OF HUMERUS

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Three cases are included in this report: one fracture of the surgical neck of the humerus, and two epiphyseal separations of the upper end of the humerus. These cases have been selected from a series of twelve involving the upper end of the humerus, and are divided as follows: nine fractures of the surgical neck of the humerus and three epiphyseal separations of the upper end of the humerus. All cases had marked displacement. The ages of the patients ranged from nine to eighteen years. These cases are being presented because they represent the average functional results which were obtained in seventy-five per cent. of such cases, and because they illustrate some of the difficulties and complications which are frequently encountered in injuries of this type.

A review of the surgical literature of this type of injury shows that very little is said regarding the difficulty in reducing these fractures and dislocations and emphasis is not placed on the fact that the functional results of the shoulder and arm would be seriously interfered with by a failure to secure good anatomical position, due, of course, to the wide range of motion in the shoulder joint. We have found that a failure to secure good anatomical position as greatly affects the growth of the bone as do injuries to the epiphysis.

We believe that reduction of these fractures should always be attempted with the patient in bed and with the aid of a portable fluoroscope. A general anaesthetic should always be administered unless the condition of the patient contraindicates. It is our practice to have a careful general examination made before any anaesthetic is administered and a thorough study of roentgen rays before any type of reduction is attempted.

Reduction by the closed method is often difficult in these cases because of the frequent periosteal attachments and the lack of control of the humeral head and the frequent rotation of the head in the epiphyseal separations, and on account of muscle pull and muscle interposition in fractures of the surgical neck of the humerus. However, we believe that the closed method should always be attempted. Great care should be taken during manipulation to prevent further injury to vessels, nerves and muscles.

After a proper reduction, it is necessary to keep a continuous traction to prevent the fragments from coming out of line. This is relieved by placing the traction with aid of adhesive to arm, having arm at a right angle

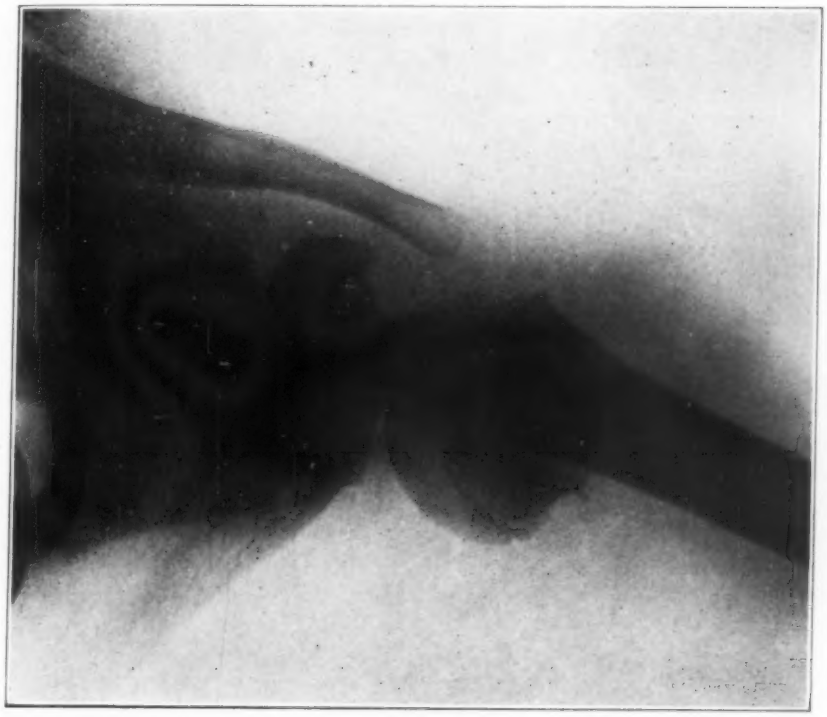

FIG. 1.

CASE A. B. Showing epiphyseal separation of upper end of left humerus with rotation of epiphyseal head.

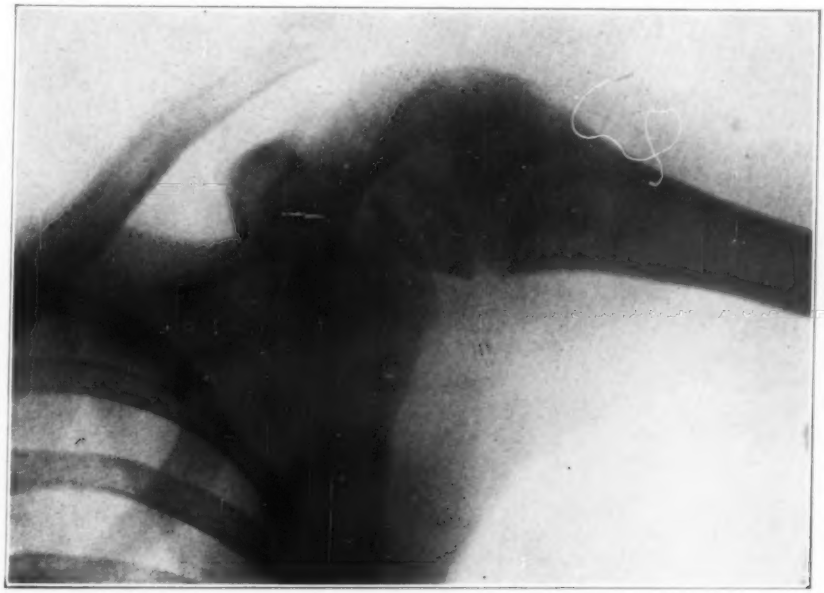

FIG. 2.

CASE A. B. Shows union and position three months following injury.

to body, and with right angle abduction frame which is attached to the bed. In the majority of the cases of the humeral epiphyseal separations, the traction with adhesive from upper one-third of arm to elbow, with arm in right angle abduction to body with ninety degrees external rotation and with forearm at right angle to arm, was sufficient. In the surgical neck fractures of the humerus, the traction was applied and abduction frame used and in the majority of these cases the arm was placed in forty-five degrees abduction and ninety degrees external rotation, with forearm in right angle flexion to arm. Absolute fixation with this form of abduction method, with patient in bed for first sixteen to twenty days, was found necessary. Daily radiant light should be applied to the injured area with frequent checks with roentgen ray.

Patient is then allowed out of bed and some form of abduction splint applied which can easily be removed every day or so to allow active and passive motion, diathermy, and massage. Diathermy should be used daily after allowing patient out of bed. Active and passive motion should be commenced at the earliest possible date. All splints should be removed as soon as possible. The type and severity of the fracture and age of the patient determine the time. No splint should be applied that cannot be

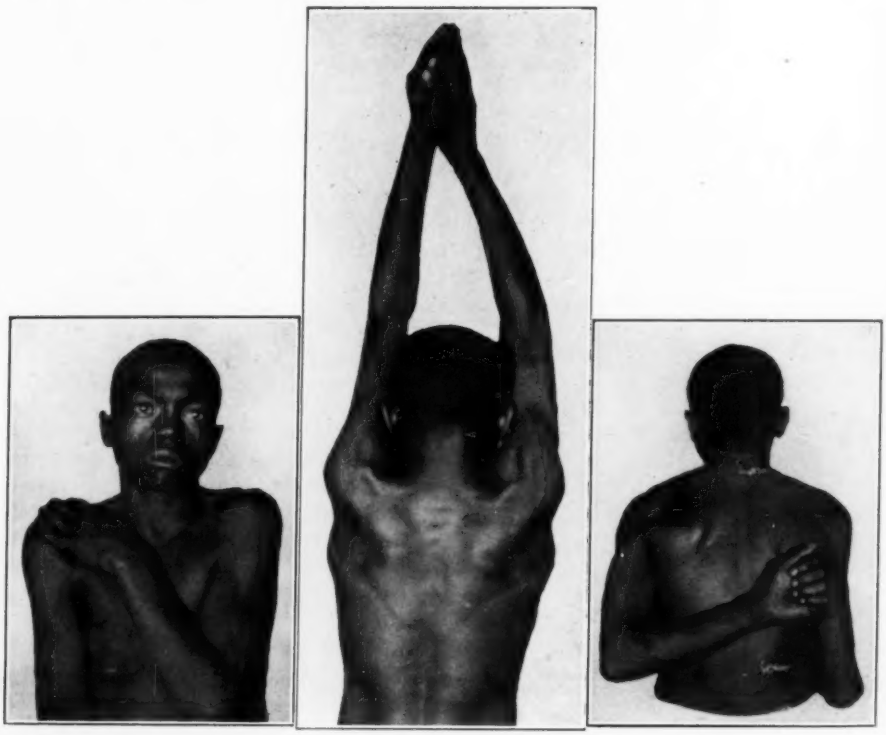

FIG. 3 FIG. 4 FIG. 5

CASE A. B. Showing functional results obtained four months following injury.

removed frequently for inspections and for treatment to be given the arm and the shoulder. By the use of diathermy, radiant light, active and passive motion, and hot baths the convalescence was diminished twenty per cent.

Open reduction was necessary in only one case in this series. Open reduction should be done within three or four days following injury. No metal splints, sutures or any foreign material should be used in either epiphyseal separations or fractures of the surgical neck. If the fragments are approximated, and proper traction applied with patient in bed with the arm in abduction, no malposition should occur.

CASE A. B. Negro boy, aged fourteen, injured May 18, 1924, stated that, while running along at a very fast rate, a boy tripped him, the patient falling on left arm and shoulder. He was admitted to Employees' Hospital, Fairfield, Alabama, immediately following injury. Roentgen ray showed epiphyseal separation of upper end of the humerus with head of the humerus rotated (Fig. 1). With patient in bed, ether anaesthetic was given and manipulation of left shoulder was carried out with aid of the portable fluoroscope. After four attempts epiphyseal head was reduced perfectly. Ten pounds traction was applied with the arm in right angle abduction and ninety degrees of external rotation and forearm at right angle to arm. Patient was kept in bed and traction applied for sixteen days. Frequent checks with roentgen ray showed good position. Radiant light was used daily. Patient was allowed out of bed on the eighteenth day and a

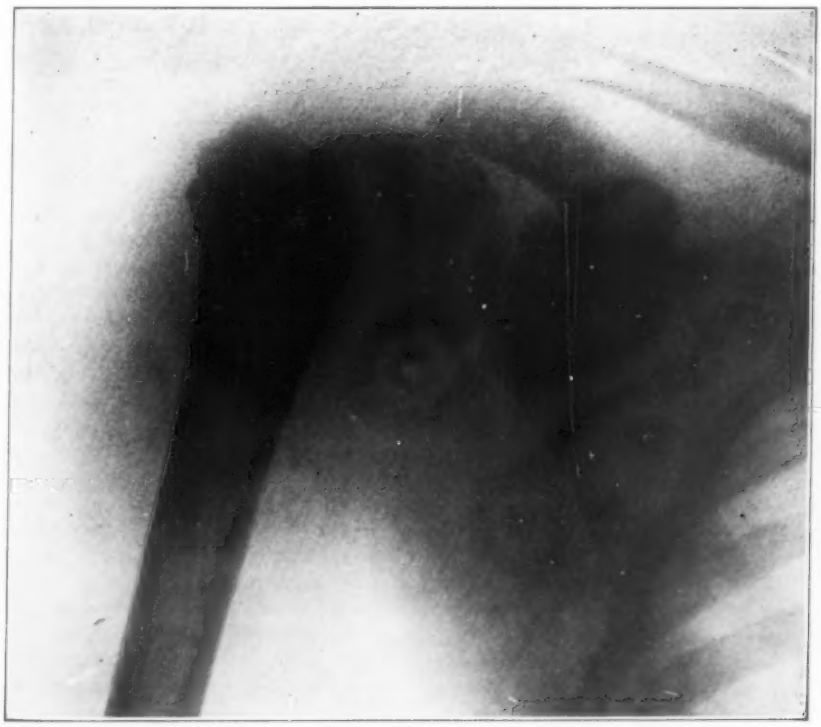

FIG. 6.

CASE N. C. Showing epiphyseal separation upper end of right humerus.

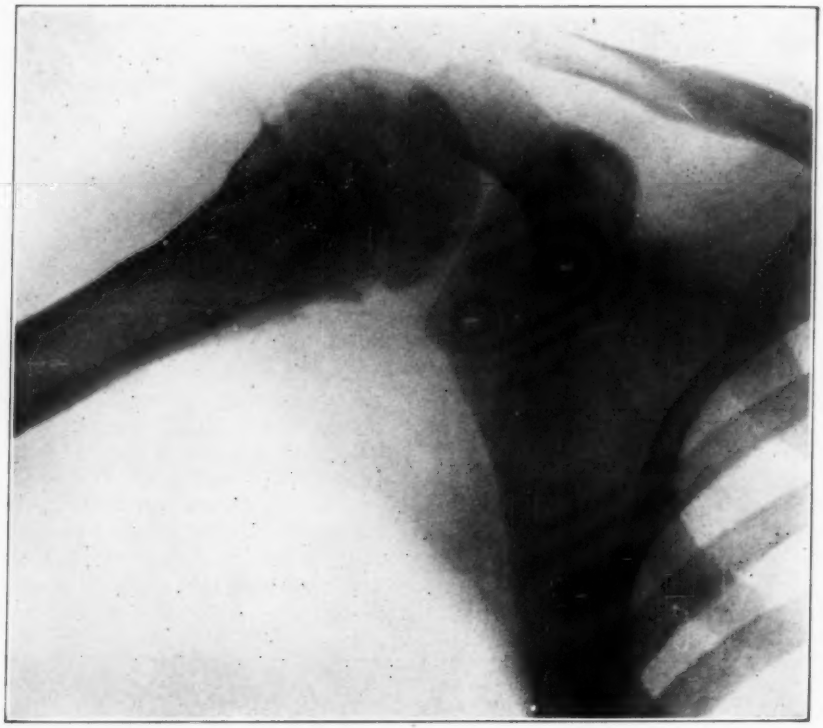

FIG. 7.

CASE N. C. Shows good union and position of epiphyseal separation three months following injury.

plaster abduction splint was applied. Arm was removed from splint daily for inspection. Diathermy was commenced with radiant light and active and passive motion daily. The boy was discharged from hospital on June 17, 1924, and he was seen daily thereafter for three weeks. Abduction splint was removed June 20. Six weeks following injury patient was able to raise arm to right angle to body without any support whatever. Roentgen ray three months following injury showed good union and good position (Fig. 2). All forms of treatment were discontinued after ten weeks except hot baths and active and passive motion. At the end of three months patient had normal functional results (Figs. 3, 4 and 5).

CASE N. C. Negro boy, aged fourteen, gave history of having rock fall on his right shoulder on March 19, 1925. He was admitted to Employees' Hospital, Fairfield, Alabama, on date of injury. Roentgen ray showed epiphyseal separation of upper end of right humerus (Fig. 6). With patient in bed, ether anaesthetic was given and with aid of fluoroscope manipulation of the right shoulder was carried out and a complete reduction of the epiphyseal separation of the humerus was accomplished after three attempts. Ten pounds traction was applied, arm was placed in right angle abduction to body with ninety degrees external rotation. The patient remained in traction seventeen days, during which time radiant light was given daily to right shoulder and arm. Frequent checks with roentgen ray showed good position. After this, patient was allowed out of bed and a right angle abduction plaster splint was applied. Arm was taken out of splint daily and given diathermy, hot baths, and massage. He was discharged on April 14, 1925, but was seen at the clinic daily for three weeks, during which

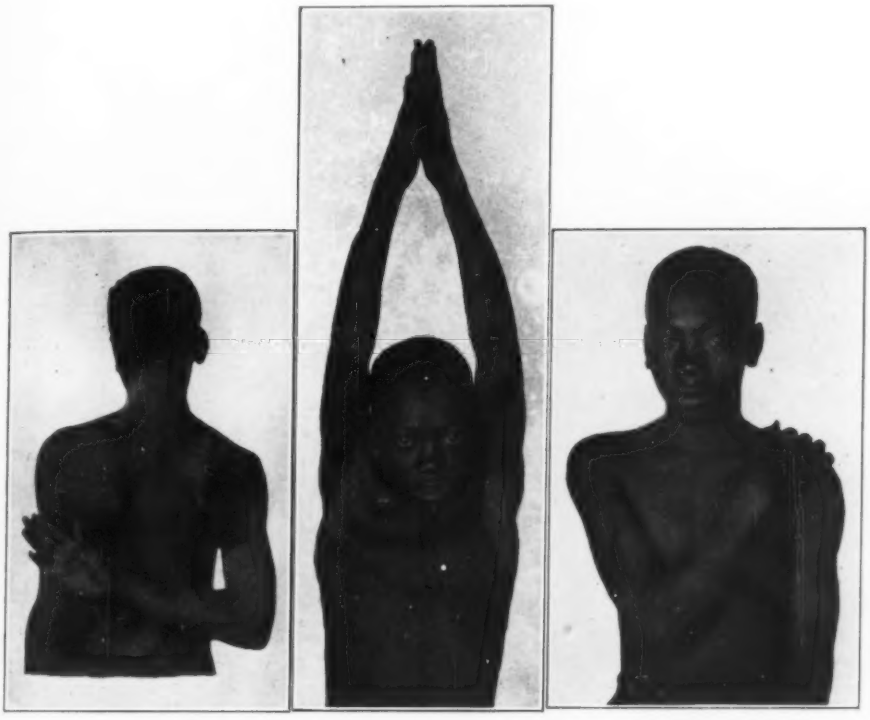

FIG. 8. FIG. 9. FIG. 10.

CASE N. C. Showing full functional results of epiphyseal separation right shoulder fourteen weeks following injury.

time diathermy and radiant light were applied. All splints were removed permanently on April 20. Patient gradually improved and at the end of the above period diathermy was given only three times a week for three weeks, and then discontinued; and only hot baths and active and passive motion were used thereafter. Roentgen ray three months following injury showed good union and good position (Fig. 7). Three months following injury patient had normal functional results of right shoulder (Figs. 8, 9 and 10).

CASE H. R. White boy, aged fourteen, was admitted to Employees' Hospital, Fairfield, Alabama, on August 31, 1925, with history of having received contusion of left shoulder by being thrown out of automobile twenty-four hours previous to admission. Roentgen ray showed fracture through surgical neck of left humerus with marked displacement of distal fragments (Fig. 11). With patient in bed, ether anaesthetic was given on August 31, 1925, and with the aid of the fluoroscope repeated attempts were made to reduce the fracture. It was possible to improve the position, but the fragments would not stay in place either with right angle abduction splint and traction or with any other method. It was readily seen that too much trauma would be done if closed reduction was further attempted. Open reduction was decided upon. Ether anaesthetic was given September 4, 1925, and open reduction was accomplished by making an incision over the deltoid muscle and separating the deltoid fibres. Fracture was easily exposed. It was found that the patient had a muscle interposition, but this was overcome without difficulty and approximation easily accomplished. No foreign fixation material was used. After the fragments were approximated, and after the arm was placed in traction with arm in forty-five degrees of abduction from body and forearm in right angle to arm, fragments remained in place without any attempt at subsequent

FIG. 11.

CASE H. R. Showing fracture of surgical neck upper end of left humerus with marked displacement of fragments.

FIG. 12.

CASE H. R. Showing good union and position of fracture of surgical neck upper end of humerus three months following injury.

malposition. Patient was allowed to stay in bed eleven days, but in this case a circular plaster cast was applied around entire body and arm and forearm. The boy was discharged on September 16, 1925. 'Operative wound healed in a few days after discharge. Ten days after discharge the top of this cast was removed so the arm could be taken out of the cast daily and diathermy and radiant light were given. Patient was kept in plaster splint for twenty-one days and then the splint was removed entirely and a wooden abduction splint was applied for one week. In the meantime, the patient received active and passive motion, radiant light, and hot baths. At the end of three months roentgen ray showed good union and position, (Fig. 12), and all treatment was discontinued except hot baths and active and passive motion. At the end of fourteen weeks following operation patient had normal functional results (Figs. 13, 14 and 15).

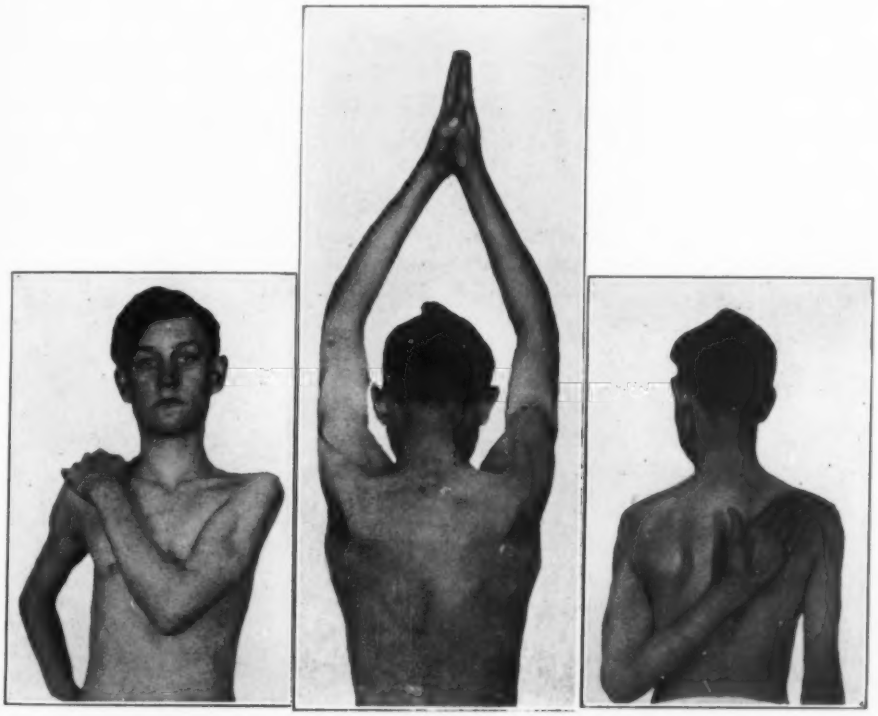

FIG. 13. FIG. 14. FIG. 15.

CASE H. R. Showing full functional results of fractured neck of humerus four months following injury.

SUMMARY

1. In the marked displacement of the surgical neck fractures and epiphyseal separations of upper end of humerus, reduction by closed method is often very difficult.

2. Majority of such injuries could be reduced by the closed method with aid of the portable fluoroscope; and a fair trial at the closed method should always be attempted before open reduction is carried out.

3. Careful study of all shoulder injuries should be made by roentgen

ray and physical examination done before any procedure whatever is carried out.

4. Patient should be given anaesthetic in bed, and reduction followed by traction and abduction frame which is attached to bed. Frequent check with roentgen ray should always be made.

5. When doing manipulations under closed method, great care should be exercised to prevent further injury to blood vessels, nerves and muscles.

6. In the epiphyseal separations of the upper end of the humerus, right angle abduction of arm to body and ninety degrees of external rotation should be used. Forty-five degrees of abduction and ninety degrees external rotation is all that is necessary in the surgical neck fractures. Some form of removable abduction splint should be applied immediately after patient is allowed out of bed.

7. No foreign fixation material such as metal plate, nails, bone pegs, etc., should be necessary if proper reduction and continuous traction is carried out.

8. All forms of splints should be permanently removed as early as possible, active and passive motion with radiant light, diathermy and hot baths should be carried out from earliest date possible. The above method has diminished period of convalescence as much as twenty per cent.

CONGENITAL DISLOCATION OF THE HIP: CELLULOID CASTS FOR INFANTS

BY EDWIN W. RYERSON, M.D., CHICAGO, ILLINOIS

Congenital dislocation of the hip joint should be reduced at the earliest moment, because the reduction can be made in infancy with the greatest ease and with the smallest amount of injury to the head of the femur. It is probable that the deformities of the head of the femur, such as flattening and coxa vara, so often developing years after successful reduction, are due in large part to traumatism occurring during the operation on children whose age has made the reduction difficult.

Many orthopaedic surgeons are in the habit of advising that the reduction be delayed until the child has reached the age of three or four years because younger children have not been trained to control the urine and feces, and as a consequence the ordinary plaster-of-Paris spica becomes softened and unsanitary. Various methods of protecting the plaster, as with oiled silk, varnish, rubber and so forth, have given little satisfaction.

Many years ago the writer was urged to operate upon an infant of fifteen months, because the father, an unusually intelligent man, had become convinced that the earlier the dislocation could be reduced, the more nearly perfect would be the result. His reasoning seemed sound, although at that date very little was definitely known about the changes which sometimes occur in the head of the femur subsequent to operation. The following procedure was adopted: Under general anaesthesia the dislocation was reduced with almost ridiculous ease. A stockinet undergarment was applied, with thin felt pads over sacrum and anterior superior iliac spines. Lead strips were placed next the skin to facilitate the cutting of the plaster cast.

A light plaster-of-Paris spica was rapidly applied, with the thigh and leg in the usual position of right angled abduction. As soon as the cast had hardened sufficiently, it was cut and removed with as little damage as possible, and bandaged together in its original shape, to be sent to the brace-maker. Another cast was applied to hold the reduced hip in the proper position. This second cast was protected with oiled silk, tucked in, and sewed carefully, in the hope that the cast would be protected until the permanent apparatus could be constructed.

The brace-maker poured liquid plaster into the first cast, making a mould which was placed in an oven for twenty-four hours to dry. Stockinet was then stretched over it and was painted with celluloid dissolved in acetone. When the first coating was dry, two more coats of celluloid were applied, and another layer of stockinet was put on. This again was painted with three coats of celluloid, and a final layer of stockinet was

similarly treated. These processes occupied four or five days. After being allowed to dry and season for two more days the cast was cut into two coronal halves, and the inside of each half was thickly painted with celluloid. This made a smooth, polished apparatus, absolutely waterproof and very easily cleaned. The two halves were joined by brass hinges riveted on the body portion of the side opposite the operated hip. Straps and buckles were riveted at frequent intervals along the edges of the leg, thigh, and opposite side of the body portion.

When this apparatus was completed, the plaster-of-Paris cast was removed from the baby without anaesthetic, and the celluloid cast was easily applied and strapped.

Details of the management were simple. The child could be laid on the back, the front half could be lifted up for bathing, powdering, and inspection, and the same process could be repeated on the back by turning the child over. Pieces of bandage secured the leg and the thigh to either half of the cast when the other half was removed. Thin felt pads could be placed over any bony points where too much pressure occurred.

The experience in this first case was so highly satisfactory that the method has been used in several other instances with complete success. The only reasons why it has not been used much more frequently are, first: that it is rather expensive, and second: that nearly all the cases of congenital hip dislocation seen by the writer have been so old or so well trained that the ordinary plaster-of-Paris could be used successfully.

FIG. 1
Roentgenogram of June 12, 1924.

SPONTANEOUS REDUCTION OF A RIGHT HIP JOINT IN A BILATERAL CASE OF CONGENITAL DISLOCATION OF THE HIP

BY ALEXANDER M. STEINFELD, M.D., COLUMBUS, OHIO

A girl, twenty months of age, was referred to the author by Dr. E. M. Freese of Columbus, Ohio, on June 12, 1924. She was the only child and her history showed that birth had been normal and that her only illness had been whooping cough. As soon as the child began to walk, the mother noticed that the child limped and she has limped ever since.

A complete examination of the child was not possible at that time as she could not be controlled, but as she lay on the table kicking her legs she appeared as a healthy, well nourished baby. The left leg was shorter than the right and the right knee adducted. From a very superficial examination it appeared that both hip joints were dislocated. This diagnosis was confirmed by the roentgenogram (Fig. 1). Immediate operation was advised but refused.

The author did not see the child again until January 5, 1926, when she was three years and three months old. She walked into the office with Dr. Freese who said that the child had a dislocation of the left hip joint.

FIG. 2
Roentgenogram of January 5, 1926.

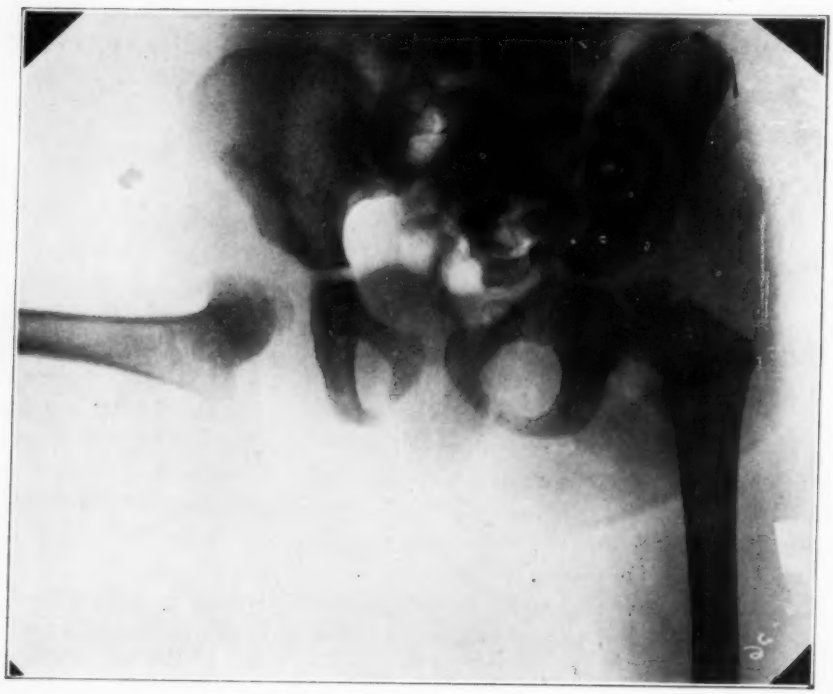

FIG. 3
Roentgenogram following operation.

Reference to the roentgenogram of June 12, 1924, showed that at that time both hips were out. A second roentgenogram was taken on January 5, 1926 (Fig. 2), which showed the right hip reduced and the left hip unreduced.

Again operation was advised and was performed at the Grant Hospital, on January 6, 1926. Under gas-ether anaesthesia the left hip was reduced (Fig. 3). Apparently this was one of the rare cases of a spontaneous reduction of a congenital dislocation of the hip.[1]

REFERENCE

1. Sloman, H. C.: On the Spontaneous Recovery of Congenital Dislocation of the Hip, J. Bone and Joint Surg., VI, 38–49, January, 1924.

A PRELIMINARY REPORT OF TWENTY CASES OF HIP JOINT TUBERCULOSIS TREATED BY AN OPERATION DEVISED TO ELIMINATE MOTION BY FUSING THE JOINT*

BY RUSSELL A. HIBBS, M.D., NEW YORK

An attempt has been made by the operation described to produce a fusion of the hip joint by an extra-articular method, similar to that used in the treatment of tuberculosis of the vertebral articulations.

Many attempts have been made to fuse this joint by operative procedures designed to secure bone contact between the head of the femur and the acetabulum. In most instances these attempts have failed; certainly this has been the experience of this clinic.[1]

Most cases of hip joint tuberculosis begin in early life before ossification of the head of the femur or the acetabulum is complete. This would seem to make fusion at that age by such means difficult, if not impossible, while at a later period when ossification is more complete, both the head of the femur and the acetabulum have been so profoundly affected by the disease and by the atrophy of disuse that though contact may be secured, sufficient bone growth will rarely take place to produce a solid fusion of the joint.

Therefore it would seem that some other means must be used, one which is outside the joint and makes contact of healthy bone with continuity of the periosteum. This has been done in these twenty cases by transposing the trochanter so that it makes contact with the ilium above and with the femur below and at the same time secures continuity of periosteum.

An incision is made through skin and subcutaneous tissue from two inches behind and above the anterior superior spine, down over the great trochanter, three inches on the shaft of the femur. The deep fascia is split, the tensor fascia femoris retracted medially, and the fibre of the gluteus medius and minimus separated by blunt dissection, exposing the capsule. The periosteum of the femur is incised along the line of the base of the trochanter, elevated and retracted medially; the anterior three-fourths of the trochanter with two inches of the cortex of the femur is separated with a chisel, leaving the muscle and periosteal attachments undisturbed (Fig. 1).

The capsule is split, the superior aspect of the neck exposed and the cortex removed. A mass of the ilium including the upper rim of the acetabulum is elevated without disturbing the muscle or periosteal attachments or breaking loose the mass above. The trochanter is now transposed by turning its lower end up under the elevated mass of the ilium, its base

*Read before the American Orthopaedic Association, April 27, 1926.

making snug contact with the cancellous bone of the neck, the cortex having been removed. The periosteum of the transposed bone is sutured to that of the iliac mass above and to that of the femur below. The mass is also caught by the tip of the remaining one-fourth of the trochanter; when the thigh is abducted fifteen degrees and flexed thirty degrees, it is held securely in place. The muscles and fascia are closed with sutures of plain catgut, the subcutaneous tissues with plain gut, and the skin with silk. A double spica plaster is applied, which has already been prepared and bivalved. By this means direct and massive bone contact has been secured between the ilium and the femur, with continuous periosteum which produces a situation favorable to bone growth, and essentially similar to the situation produced by spine fusion, where the continuity of bone and periosteum is primarily of healthy bone which first becomes fused; ultimately, however, fusion of the diseased bodies takes place. It was hoped that in the case of the hip the primary fusion would be of the transposed trochanter, ilium and femur and ultimately of the head and acetabulum as well, finally showing a massive area of fusion which is necessary to stand the force exerted upon it by the long femur (Figs. 2 and 3).

This technic was developed on the cadaver in the Department of Anatomy at the College of Physicians and Surgeons, Columbia University, in 1922. The first case operated on was on April 5, 1923.

In looking up the literature in preparation of this report it was found that a somewhat similar procedure was reported by J. Hass.[2] Our work was completed without knowledge of this fact.

In the first twenty cases only, has sufficient time elapsed since operation to make possible any fair estimate of the result and even in these the report must be considered as preliminary. A longer time must have elapsed and a larger number of cases be studied before any final conclusion may be reached as to the value of the operation. Of these twenty cases eighteen, or ninety per cent., are

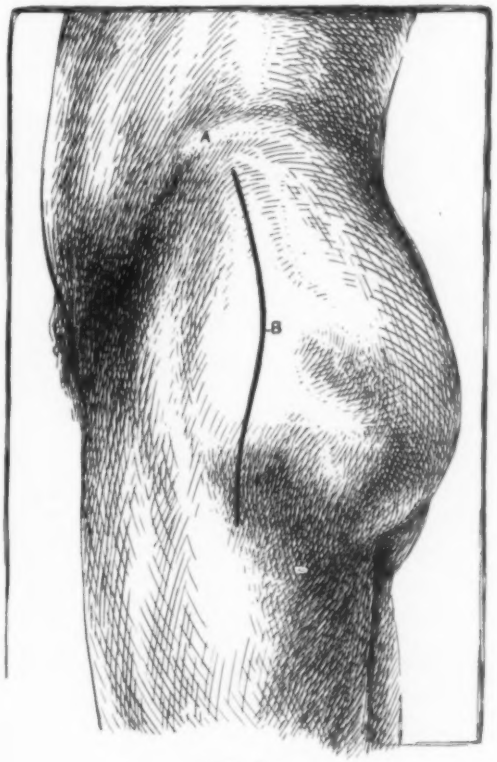

FIG. 1

A. Antero-superior Spine
B. Skin incision

definitely fused, as determined by stereoscopic x-ray pictures, careful examination for mobility, and the disappearance of all spasm or symptoms of active disease, with unrestricted activity in the use of the leg for varying periods of time, from two and one-half years to six months in the most recent case. One patient was four years old, one six, and three were nine years old. The other fifteen varied up to thirty-one years, the oldest patient. Much interest lies in the results in the younger patients, because, to be of the greatest service, any such operation must be applicable to young children, at which age most cases of the disease begin, and when compensation in the use of a stiff hip is easily attained. The six year old child, the second case operated on, has a firmly fused joint in good position. There is no evidence of activity of the disease and her general condition is excellent. At the time of operation the disease was advanced and very active. The youngest patient was a girl four years of age. The technic in this case was faulty in that the osseous center of the transposed trochanter was not placed in contact with the denuded bone of the neck, although it was firmly fixed in the ilium. The result at the end of a year was a well developed block of living bone, firmly incorporated with the ilium but not attached by bone to the femur. A revision was undertaken by which a bridge of bone was made to fill the gap. Subsequent x-rays have shown a progressively increasing mass of bone with ultimate firm union of the femur to the pelvis. This case demonstrates the possibility of transposing the trochanter and having it incorporate itself with the surrounding bone while remaining viable. The three nine year old cases have all achieved a firm, bony arthrodesis and arrest of disease.

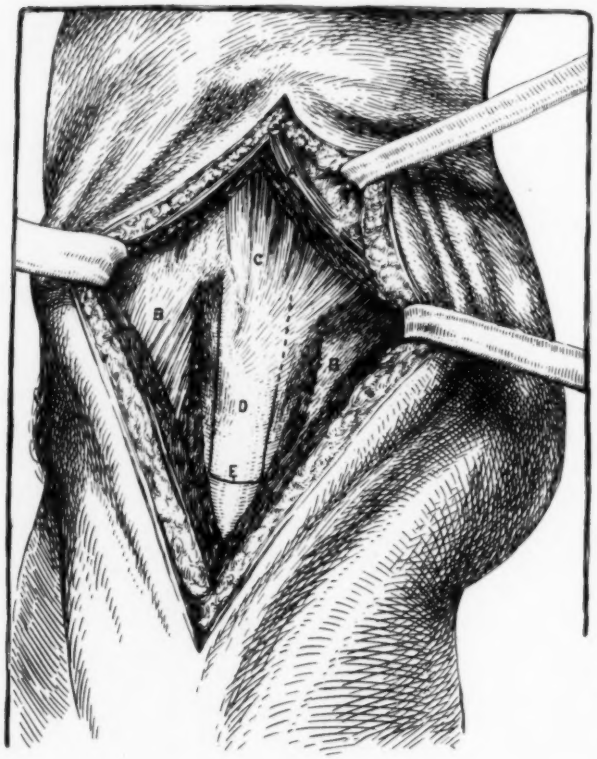

FIG. 2

A. Tensor Femoris muscle divided
B. Vastus muscle divided
C. Gluteus Medius and Minimus muscles
D. Trochanter and Shaft
E. Chisel line cut in Trochanter and Shaft

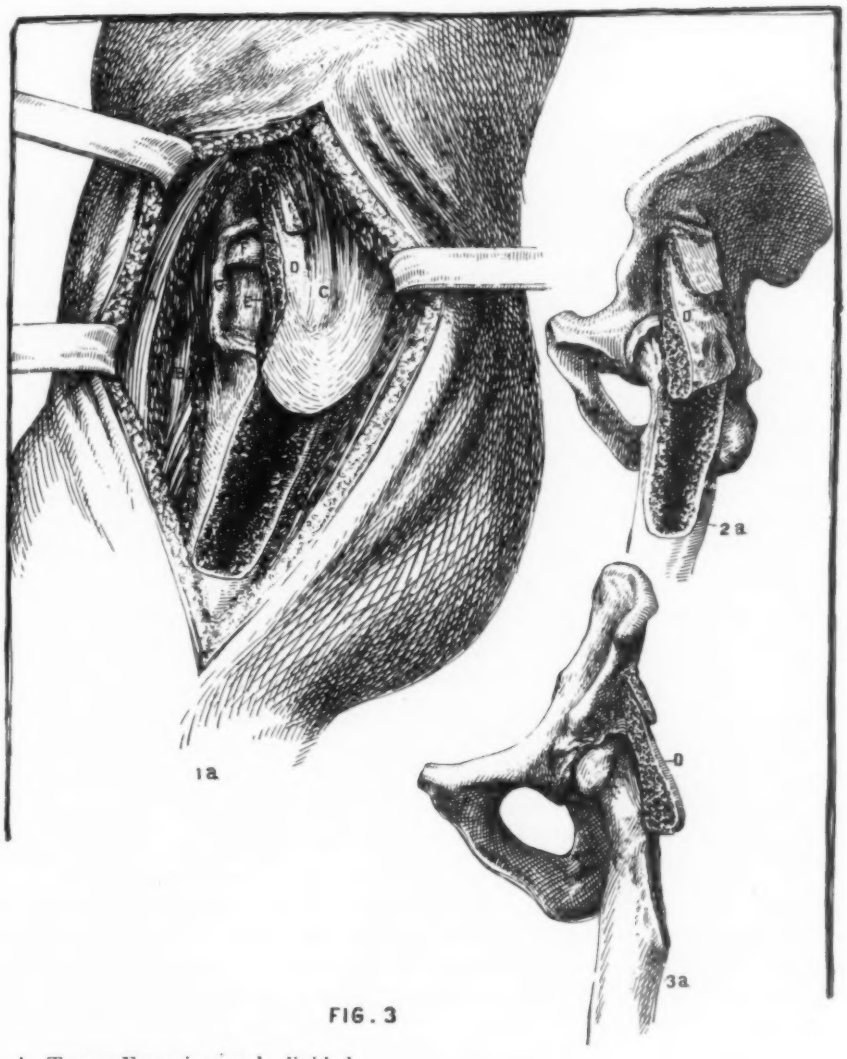

FIG. 3

A. Tensor Femoris muscle divided
B. Vastus muscle divided
C. Gluteus Medius and Minimus muscles which were cut through anteriorly and above Trochanter
D. In 1a, 2a, and 3a Trochanter turned up with lower end under Iliac bone flap
E. Raw bone superior surface of neck of Femur
F. Head of Femur in Acetabulum
G. Capsule of joint

The fusion which has taken place in these cases appears to have been primarily of the transposed trochanter, ilium and neck of the femur, but finally of the remaining head and acetabulum as well. This process is very similar to that which takes place in vertebral tuberculosis, in that the fusion is primarily of the healthy bone of the posterior elements of the vertebrae and finally of the diseased bodies.

With two exceptions the disease in this series of cases was of long standing and the destructive process was extensive. The average duration before operation was eight and one-half years. In one case it was twenty-six years, in one sixteen years, in another fifteen years, and in two thirteen years. Two patients had had symptoms for only six months, and in these the diagnosis was proved by exploratory operation. Since contact of bone between the head of the femur and the wall of the acetabulum is not depended upon, the difficulty of doing the operation is not increased by the disease of these elements. On the contrary, proximity of the trochanter to the ilium makes the procedure easier. The trochanter itself was extensively diseased in one case but the result was in no way compromised by this fact.

In all of the cases the disease was active as evidenced by pronounced muscle spasm and limitation of motion. X-rays at the time of operation showed more or less extensive destruction of the head and neck of the femur and of the acetabulum. The general condition of the patient was good in seventeen, fair in two and poor in one.

Several of the cases had had sinuses which were healed at operation. One of these sinuses began to discharge slightly after operation but is now closed. Two sinuses open at the time of operation have since become healed. The one death in the series occurred in the case of a colored man twenty-one years old. He had pleurisy a few months before operation and was in poor condition. The disease in his hip was active and a large abscess was present. He succumbed to miliary tuberculosis nine months after operation. Several sinuses were discharging and the hip was not fused.

These twenty patients had been treated in this hospital for an average of about six years and some of them had been treated for years in other hospitals. Six had been cared for at the Country Branch of the New York Orthopaedic Hospital for periods of from three to seven years. The majority of them had worn apparatus for many years. This group is quite typical of the cases of hip joint tuberculosis seen at this clinic and illustrates the hopelessness of dealing effectively with this condition by the old conservative methods.

In the main the same technic was used in all of these operations, but minor modifications and improvements were made until the procedure described above was arrived at. In twelve cases the wounds healed by primary intention. Six developed small sinuses in the wound, all of which healed at the end of a few months. One had a severe operative infection, still has two sinuses discharging profusely and the result of the fusion is doubtful (Series 19, Case 22385). One developed sinuses in the wound and died of miliary tuberculosis nine months after and the hip was not fused (Series 5, Case 67557). A rather severe postoperative reaction with shock occurred in two cases. After that a plaster spica was prepared before operation, bivalved and warmed while the operation was being done. This eliminates all delay and manipulation while applying the plaster after the operation and substitutes a dry, warm plaster for a wet, cold one. This,

together with improvement in the technic, has done away entirely with shock and the course after the operation has been smooth.

Immobilization in plaster spicas was continued for an average of ten months. Walking in the plaster spica was started at about the ninth week in the earlier cases and at the end of the twelfth week in the later ones. It is customary to change the bivalved plaster into which the patient is placed after operation for a more permanent one at the end of the third week, at which time the wound is dressed.

A problem arose in some of the older cases of long duration in which the hip was badly flexed and adducted with slight mobility at the time of operation. A number of these were left practically in this position because it seemed inadvisable to traumatize the joint to the extent necessary to accomplish correction. In one case the adduction has been corrected by a subtrochanteric osteotomy and this procedure will be necessary in one other.

Since no attempt was made to open the old joint cavity, it was difficult in some cases to obtain tissue from a region in which the disease was active. Twelve positive reports for tuberculosis were received from the laboratory. In eight the examination was doubtful, although in practically all a guinea pig inoculation, as well as tissue section, was carried out. With the long duration of the disease, x-ray and clinical findings all corroborating the diagnosis, there seemed no doubt whatever as to the character of the lesion in any of the cases.

CASE HISTORIES

1. H. H., 18307, a boy, 18 years old at time of operation. Pain and stiffness started in right hip at two years of age. He was admitted to the New York Orthopaedic Dispensary and Hospital three and one-half years before operation. The right hip was flexed 40 degrees, adducted and internally rotated. Motion was slight. A discharging sinus was present and still was active at the time of operation. X-rays showed complete destruction of the head of the right femur and a remnant of neck still in the acetabulum. A hip splint was applied and was worn for three and one-half years. Operation for hip fusion was performed on April 5, 1923, and the leg was placed in a plaster spica in 20 degrees flexion and slight abduction. The wound healed by primary union. Walking in plaster was started two and one-half months after operation. The patient remained in the hospital for three months and the last plaster cast was removed at the end of eleven months. The hip seemed perfectly solid eight months after operation. The last x-ray showed solid union of the transposed trochanter to the ilium and femur. The sinus is closed and there is no evidence of active disease.

2. A. S., 60963, a girl six years old, was first treated at the clinic three months before operation. The history of limp, pain and stiffness in the left hip extended back four years, the onset being at two years. There was marked atrophy of the left lower extremity with extreme muscle spasm which greatly limited motion in the hip. X-ray showed disappearance of the joint space and destruction and cavitation of the wall of the acetabulum. She had worn a plaster spica for seven months and a Taylor hip splint was applied at the time of admission. Hip fusion operation was performed on April 11, 1923. The patient was transferred to the Country Branch of the hospital, where she still is, although there has been no sign of active disease for two and one-half years. The plaster spica was removed thirteen months after operation, at which time the hip appeared to be firmly fused. X-rays show the trochanter in the new position with much

new formed bone around it. The child runs and plays actively, with no pain or spasm. She has learned to compensate for the stiff hip in a remarkable manner.

3. A. E., 19900, a boy 17 years of age. Symptoms began in the right hip at four years of age and he first came to the Orthopaedic Hospital for treatment at eleven years of age. He wore a hip splint for two years and the condition then became quiescent for four years. The symptoms returned about three months before operation. X-rays then showed a loss of substance both of the acetabulum and head of the femur. The hip was flexed and markedly adducted. At operation, July 20, 1923, it was felt that the adduction could not be overcome without unwarranted trauma and the hip was put up without changing this deformity. The patient remained in the hospital two and one-half months at which time weight-bearing was begun. The hip seemed firmly fused at the end of four months and the plaster was removed. In December, 1925, a subtrochanteric osteotomy of the right femur was done in order to correct the adduction. X-rays show the transposed trochanter in the new bed with abundant new bone around it. The hip is solid and there is no pain or muscle spasm.

4. M. D., 15831, a girl 17 years old, came to this clinic at the age of two years with limitation of motion and muscle spasm about the right hip. She was treated for ten years with a Taylor hip splint. In 1923 she still had slight muscle spasm and pain in the hip which was flexed and adducted about 10 degrees with approximately 10 degrees of motion in flexion and extension. The x-rays showed a deepening and erosion of the acetabulum and only slight destruction of the femoral head. The operation was performed on September 18, 1923. The hip was placed in a plaster spica in flexion and abduction. Weight-bearing was begun in two months. She remained in the hospital two and one-half months and the plaster was removed in ten months. Fusion appeared to be solid in eight months. The x-rays show apparently complete arthrodesis. All muscle spasm and pain have entirely disappeared.

5. E. M., 67557, a colored man aged 21 years, began to have pain and stiffness in the left hip three months before admission to the hospital. He was in poor general condition and had had pleurisy with effusion during the past year. No signs of active tuberculosis could be found in the lungs. There was marked muscle spasm and limitation of motion in the left hip. A fluctuating swelling over the anterior surface of the hip was aspirated and thin pus was obtained from which a positive diagnosis of tuberculosis was made. X-ray showed slight thinning of the joint space and a small translucent area in the roof of the acetabulum. Operation for hip fusion was performed on December 4, 1923, six months after onset of symptoms. An abscess was found overlying the joint. The general condition remained poor after operation. Sinuses formed communicating with the abscess. The patient was discharged from the hospital four and one-half months after operation. He was later admitted to Sea View Hospital, where he died from general miliary tuberculosis nine months after operation. The hip had not become fused.

6. S. D., 39123, a girl nine years old, began to have pain, stiffness and limp in left hip when three and one-half years old. She came to the New York Orthopaedic Hospital for treatment when five and one-half years old and wore the regulation Taylor hip splint for two and one-half years while receiving dispensary treatment. At the time of operation, December 14, 1923, she still had muscle spasm and pain. The hip was flexed 50 degrees and adducted 15 degrees. About twenty degrees of motion was present. The x-ray showed almost complete destruction of the head and neck of the femur, with the remnant of the neck in an eroded acetabulum. Following operation she was in shock from which she rapidly recovered. At the end of three weeks she was transferred to the Country Branch of the hospital, from which she was taken against advice eleven months after operation. Walking was started two months after operation. The hip seemed solid six months after operation, but the plaster was not removed until thirteen months. The hip was perfectly solid and there is absence of pain and muscle spasm. The x-ray shows the trochanter solidly fused to acetabulum and femur.

7. W. B., 22654, a man 22 years old, began to have symptoms in left hip when

fifteen years old. One year later he came to the New York Orthopaedic Hospital for treatment and was cared for in the dispensary for four years, during which time he wore a brace. His symptoms then disappeared and he was free from pain, etc., for one and one-half years, when they recurred. Before operation he had pain and muscle spasm. Motion was limited to about 5 degrees. X-rays showed marked destruction of the acetabulum and a spicule of the neck remaining. A sinus which had been discharging was closed. The hip was flexed 45 degrees and adducted. Operation was performed on February 15, 1924. No attempt was made to correct the adduction. He remained in the hospital three months and the plaster spica was removed in thirteen months. The hip is firmly fused and the x-ray shows union of the trochanter to the neck and ilium. All symptoms have disappeared.

8. V. C., 17271, a boy 14 years old, first had symptoms in right hip when seven years old. Two and a half years later he came to the hospital for treatment and was sent to the Country Branch of the hospital for three and a half years, when he was discharged, apparently cured. One year later he again had pain, muscle spasm, etc., in the hip. There was about 10 degrees each of flexion and adduction. The x-ray picture was that of deepening and erosion of the acetabulum. He was operated upon February 19, 1924. An abscess was found in the trochanter, but this was employed in the usual way regardless of the pathological condition. The patient walked at the end of two months and left the hospital three months after operation. Fusion seemed to be complete in five months and the spica was removed in nine months. The joint has remained perfectly solid and free from symptoms. X-rays indicate that bony fusion has taken place.

9. R. G., 41771, a girl nine years of age. Stiffness in right hip and limp began when she was five years of age. She was brought to the hospital six months later and was treated for three years at the Country Branch. When discharged the hip was quiescent, but symptoms reappeared in six months and the disease appeared to be slowly progressing. The hip was flexed 20 degrees, adducted 10 degrees and very little motion was present. X-rays showed marked irregular destruction of the head and neck of the femur and obliteration of the joint space. She was operated upon March 9, 1924, and has remained in the Country Branch since then. She started to walk in plaster two months after operation. The hip appeared to be solid in eight months and the plaster was removed in ten months. The child is now very active and has no symptoms whatever in the hip. X-ray shows a large bridge of bone between the acetabulum and femur.

10. T. S., 3031, a boy 17 years old, began to have pain in the left hip and limped at four years of age. He came to this clinic three years later and was treated for three and one-half years at the Country Branch, at the end of which time he was apparently cured. He reported for six months longer at the dispensary. He was free from symptoms for six years more. Then following a fall the hip again became active and he was found to have only slight motion and muscle spasm. A healed sinus was present. X-rays showed slight erosion of the head of the femur and obliteration of the joint space. The operation was done on March 24, 1924, thirteen years after the onset. Weight-bearing was started nine weeks later. The hip seemed solid in eight months and the plaster was removed at the end of one year. At the time a sinus was discharging but it soon closed and has remained so. The patient is active and well; the hip is solid and there are no evidences of active disease.

11. R. M., 71722, a girl four years old began to have pain and stiffness in the right hip at three and one-half years. She was taken to the Orthopaedic Hospital three months later. All the typical signs of tuberculosis of the hip were present. The x-ray showed nothing definite. An exploratory operation was performed and the diagnosis of tuberculosis of the hip was established by section of tissue and guinea pig innoculation. On June 27, 1924, six months after onset, a hip fusion operation was performed and she was sent later to the Country Branch of the hospital. The transposed trochanter fused firmly to the ilium but failed to unite with the femur because the technic had been faulty and good contact had not been established. In April, 1925, a second operation was

performed and pieces of bone were turned up from the femur to make contact with the transplanted trochanter. This resulted in a complete bony bridge which has steadily grown larger. The hip is now solid and is free from symptoms.

12. J. M., 4151, a boy 15 years old, was first seen in this clinic when four years old. He had then had pain, stiffness and limp in right hip for six months. He was treated in the dispensary with a brace which he wore eleven years, until the time of operation. The disease was then slightly active as evidenced by pain and muscle spasm. A very slight range of motion was still present and there was a marked flexion and adduction deformity. The x-ray showed destruction of the head and neck of the femur, erosion of the acetabulum and slight upward displacement of the shaft. He was operated upon July 9, 1924, and the hip was placed in flexion and slight abduction. He stayed in the hospital for three months, at which time union seemed firm and walking was begun. The spica was removed at the end of eight months. The hip has remained solid with no symptoms of activity. It is in a position of flexion and slight adduction. The x-ray now indicates bony fusion.

13. F. C., 43748, a girl 9 years old, first had evidence of tuberculosis in right hip when five years old. She came to the New York Orthopaedic Hospital four years after with the typical findings of atrophy, muscle spasm, great limitation of motion and with the hip in flexion and adduction. The head and neck of the femur were destroyed and the acetabulum was deepened. A discharging sinus was present. She had worn a brace for three years. A hip fusion operation was performed on August 12, 1924. Weight-bearing was started in three months and the hip appeared to be solid in seven months. The plaster spica was left on for seven months. The patient has remained at the Country Branch of the hospital since operation, although she is entirely free from symptoms. The hip seems firmly arthrodesed and x-rays indicate that this is so. There is still a slight discharge from the sinus.

14. I. S., 77751, a girl 15 years of age, began to have pain, stiffness and limp in right hip when five years old. She first came to the Orthopaedic Hospital ten years later, having been treated elsewhere in plaster for two years and with a brace for eight years. The disease appeared to be moderately active and well advanced. The hip was adducted and flexed and very little motion was present. X-ray showed marked destruction of the head and neck of the femur and enlargement of the acetabular cavity. Two healed sinuses were indicated by scars. Operation was performed on November 12, 1924. Walking was begun in plaster at the end of three months. Fusion seemed firm at the end of seven months and the plaster was removed in nine months. She stayed at the Country Branch of the hospital for thirteen months. A sinus appeared after operation but closed at the end of three months. The hip is solidly fused in good position and gives no symptoms. X-ray shows fusion of the femur to the ilium through the transplanted trochanter.

15. P. L., 27493, a boy 12 years old, began to have symptoms in right hip when five years old. One year later he came to the Orthopaedic Hospital and was sent to the Country Branch, where he stayed for five years. One year after discharge from the hospital he still had pronounced muscle spasm and limitation of motion, although he had worn a brace for six years. The joint was in good position, flexed 20 degrees and abducted 20 degrees. About 30 degrees motion was possible. The x-ray showed underdevelopment and decalcification of the femur with cystic areas in the head and neck. He was operated upon November 19, 1924, and later was sent to the Country Branch of the hospital where he still is being kept under observation. He began to walk in plaster three months after operation. The hip appeared to be firmly fused at the end of seven months and the plaster was removed at the end of nine months. The hip is now flexed and slightly adducted. Fusion is firm, as indicated both by physical examination and x-rays. There are no symptoms of disease in the joint.

16. A. L., 51971, a boy 14 years old, first had pain and stiffness in right hip when five years old. He applied for treatment at the New York Orthopaedic Hospital seven years later. There were several draining sinuses about the hip, which was flexed and

extremely rotated. Motion was limited to about 30 degrees and muscle spasm was present. The x-ray showed decalcification of bone, deep cavitation of the acetabulum and marked destruction of the head and neck of the femur. A hip fusion operation was done on December 16, 1924. Weight-bearing was begun three months later and the hip seemed to be solid eleven months after operation. The plaster was removed thirteen months after operation. The x-ray shows a bridge of bone from the ilium to the femur and the hip appears to be solid. The sinuses still are discharging. There is no muscle spasm or pain.

17. E. G., 52862, a girl 16 years of age, was admitted to the New York Orthopaedic Hospital in 1922, having had pain in left hip and leg for six months. There were atrophy, muscle spasm and limitation of motion. The x-ray showed bone decalcification and thinning of the joint space. A hip splint was applied and at the end of a year the pain was gone and the muscle spasm had almost completely disappeared. Several months later the symptoms recurred and the pain became very severe and persistent. Operation was performed January 9, 1925. She was allowed to walk in plaster four months later. A sinus appeared after operation which healed two months later. The hip appeared to be solid at the end of six months, and the plaster was removed in seven months. She remained at the Country Branch of the hospital for eleven months after operation. The hip is now firmly arthrodesed in flexion and abduction and there is complete freedom from pain. The x-ray shows bony fusion of the femur to the ilium through the transplanted trochanter.

18. A. K., 68695, a man 31 years old, began to have symptoms of tuberculosis of the left hip when he was five years old. For the intervening twenty-six years he was treated at the dispensary. There were intermittent periods of activity and for a total of sixteen years he wore braces and plaster casts. At the time of operation there were still pain and muscle spasm. The hip was flexed 35 degrees and slightly adducted. Motion was practically nil. X-rays showed cavitation of the acetabulum and erosion of the head of the femur. He was operated upon February 17, 1925, and was allowed to walk three months later, at which time the hip seemed firmly fused. A sinus which formed in the incision was healed at the end of two months. The plaster was removed eight months after operation and the patient was discharged from the Country Branch of the hospital at the end of nine months. Fusion is solid as indicated both by x-ray and physical examination and all symptoms of activity have gone.

19. A. L., 22385, a boy 12 years old, had limp and stiffness in right hip when two years of age. He came to the New York Orthopaedic Hospital three years later at the age of five, and was treated for seven years in the Country Branch of the hospital, during all of which time he wore a brace. The disease in his hip progressed steadily although his general condition was good. At the time of operation the hip was flexed and extremely rotated and only about 5 degrees of motion was present. The femoral head and neck were gone, and the acetabulum was deepened and elongated. Operation was performed February 18, 1925. There was a severe postoperative reaction and it was found that the wound was infected. This infection extended to the bone and an osteomyelitis ensued. There are still draining sinuses and the result is doubtful, though it is hoped that fusion will take place.

20. J. B., 41140, a boy ten years old, had onset of symptoms in the right hip when five years of age and was taken at once to the New York Orthopaedic Hospital. He was admitted to the Country Branch six months later and remained there five years, until he was operated on. During all of this period he wore a brace. His general condition was good but he continued to have muscle spasm and limitation of motion in the hip and the x-ray showed increasing cavitation of the acetabulum and disappearance of the joint space. Operation was performed on February 20, 1925. A rather severe infection ensued but the wound finally closed completely. Weight-bearing was started in three months, and the hip appeared to be solid in four months. The plaster was removed in ten months. The patient is being kept under observation at the Country Branch of the hospital. The x-ray shows bony fusion of the femur to the acetabulum and clinically all signs of disease have disappeared.

REFERENCES

1. Farrell, B. P.: An Attempt to Fuse the Hip Joint for Tuberculosis; A report of the end result of ten cases, J. Bone & Joint Surg., VII, 563–569, July, 1925.
2. Hass, J. Extraartikuläre Ankylosierung der Hüfte. Zentralbl. f. Chir. XLIX, 1466–67, Oct. 7, 1922.

DISCUSSION

Dr. E. G. Brackett, Boston, Mass.: I think we are very much indebted to Dr. Hibbs for presenting to us this series of cases and having brought to us a very new procedure. I must acknowledge after seeing his results and his demonstration of a large mass of new bone in the ankylosis formation, that it must influence anything I intended to say, for his results are excellent and are encouraging in this difficult problem. He is giving to us an operation which allows its employment in a much earlier age than would be possible otherwise, for he operates almost entirely outside the diseased joint area, and, therefore, it removes much of the objection we have had of operating in young children during the growing stage, for fear of interfering with the epiphyseal lines.

In all these operations we must ask ourselves when in the course of the disease are we going to do it. We all know that if taken in the earlier stages of hip disease we can sometimes by selective methods and care obtain a joint that will stand function during life, but to accomplish this we must have the disease arrested at a time when the contour of the joint is not destroyed, and when the opposing surfaces are still well covered with cartilage. Under these circumstances nature has sometimes so restricted mobility as to keep the motion within an arc safe to these structures. Under other conditions, even although the disease has become quiet, the joint is so destroyed that we cannot consider motion as safe, and the real cure is a bony ankylosis. The question is how are we going to bring it about. Nature can sometimes do it, but there is a certain amount of danger in allowing her way. I think Dr. Hibbs has shown us that by operative procedure the chances are far better. Up to this time we have a great deal of uncertainty as to the surety of operative procedures, which also had some operative risks. We must therefore make our decision according to the conditions about the child. For instance, if we are unable to carry out the ordinary conservative procedure, where time is an important element, and where the patient is later to carry on an active life, we should consider operation much earlier. And until I heard Dr. Hibbs' paper and saw his results, I should certainly put the age limit much later than I would now.

One point which he did not mention, and which should be considered in undertaking the operation, viz., the angle of elevation for this ankylosis. The angle is a good deal a matter of choice, i. e., a matter of opinion. We should remember that an extended leg and hip makes a very uncomfortable leg to sit with. On the other hand, flexion of the hip even to a considerable degree not only allows a comfortable sitting posture, but ease in walking and standing, even more so than a straight leg. I believe we should err on the side of too much flexion rather than too much extension. In the lateral plane the ideal position is that which puts the foot under the pelvis, and therefore a few degrees of abduction is of very definite value and more stable than abduction, but since in these cases there is usually some degree of shortening one must sacrifice stability for length. I think we have all had the experience of getting too much abduction, and too great a degree of eversion is to be avoided.

Dr. David Silver, Pittsburgh, Pa.: Dr. Hibbs is to be congratulated, I think, because he has been able to demonstrate the possibility of obtaining a sufficient degree of ankylosis by extra-articular arthrodesis in tuberculosis of the hip. With the advantages of the extra-articular method I am heartily in accord. In tuberculous arthritis I think this operation should always be performed extra-articularly in any joint where it is possible. The advantages are obvious.

There is one interesting point he has brought out, namely that ankylosis takes place subsequently in the joint itself. Many surgeons claim it is impossible to secure a bony ankylosis in a tuberculous joint, yet, after obtaining extra-articular fixation, Dr. Hibbs has been able to secure a bony ankylosis of the joint. It may be that we do not yet know how to immobilize these joints sufficiently.

With reference to the amount of flexion in which the hip is fixed, it seems to me that in younger children this should be less than in older ones as there appears to be greater likelihood at the earlier age of an increase in flexion from long-continued sitting on the unyielding school benches.

Dr. W. S. Baer, Baltimore, Md.: I wish to thank Dr. Hibbs for bringing before us such a beautiful piece of work. Secondly, I want to congratulate the Society for having the opportunity to listen to such a piece of work, so logically and beautifully presented. I hope the day will come when we will not have to operate on tuberculosis of the hip, and trust that heliotherapy, or light in some other form, or vaccines will make operation unnecessary. However, I agree with Dr. Hibbs that in the present state of our knowledge an arthrodesis for tuberculosis of the hip is the thing to do. For some years I have been doing an arthrodesis for this condition. When the arthrodesis succeeded the result was good, but it did not always succeed.

If I understand Dr. Hibbs' operation rightly, it is not an extra-articular operation entirely, as he has indicated, because he has denuded the neck in order to make a basis for the transplanted bone, which is necessarily within the joint. I rather think that this intra-articular operation is accountable for some of his good results.

I would like to ask Dr. Hibbs just how he accounts for the great production of new bone which has taken place between the head and the acetabular cavity, a situation which was not in the operative field.

Dr. Russell A. Hibbs, New York, N. Y. (closing): The position of the femur in fusing the hip is very important. I feel quite sure that a fused hip inflected is more serviceable both in sitting and walking than a straight position. The degree of abduction is very debatable. These cases have been put up, except in a few instances, in from ten to twenty degrees of abduction. The degree of abduction should depend in some measure on the amount of shortening and will, therefore, vary in individual cases.

I am sure we are all in sympathy with the hope that Dr. Baer expresses that some remedy may be discovered which will destroy the organism of tuberculosis and save the joint. Certainly we have no realization of that hope at present, and in the light of our present knowledge and experience, so far as our clinic is concerned, we have not definitely cured any cases of hip joint tuberculosis by the older conservative methods. We find that the disease gets well in other joints which have been fused and it would seem reasonable to expect the same to take place in the hip.

CONGENITAL DISLOCATION OF THE HIP: REPLACEMENT OPERATION*

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The unreducible congenitally dislocated hip has of late been made a subject for experimentation, because of the unsatisfactory results previously obtained by the older methods. At the present time we are confronted by two new operative procedures: first, the bifurcation operation, whereby the femur is sectioned obliquely in its upper third and the proximal end of the lower fragment is inserted into the acetabulum; second, the shelf-flap method, whereby a roof is formed over the head of the femur. These procedures have as their main objectives stability and preservation of motion. The ideal method is that which replaces the dislocated femoral head in its original location, and results in increased stability, fair range of mobility and improved gait, by restoring the antero-posterior equilibrium of the body.

The following case report presents an instance where the older method of reformation of an acetabulum, with placement of the femoral head within it, was deemed the most advisable. The bifurcation operation was contraindicated because of the extreme shallowness of the acetabulum and the resultant greater shortening. The shelf operation, though considered, was not resorted to because of the extreme posterior displacement of the head of the femur. While stability would have been improved, the gait would have been as awkward as before operation, due to the failure of the method to restore the antero-posterior equilibrium of the body.

Case report: E. L., female, age 13 years, was first observed November, 1924, complaining of pain across the lower part of the back and a marked left hip limp. The history was typical of a congenital malformation. No treatment had been received prior to observation.

Examination revealed the patient to be in good general condition, but walking awkwardly with a left hip limp. The lumbo-sacral angle was exaggerated. Movements of the hip were free. The head of the femur was palpable posteriorly and could be moved in a vertical direction, thus evidencing what is known as "telescoping." The greater trochanter was found well above Nelaton's line. Mensuration disclosed two and one-half inches of shortening, one inch atrophy of the thigh and one and one-half inches atrophy of the calf when compared with the opposite limb.

* Patient presented at the Clinical Conference of the Staff of the Hospital for the Ruptured and Crippled, New York, December 22, 1925.

FIG. 1

Roentgenogram prior to operation.

The roentgenogram (November, 1924) showed a lack of development of the left half of the pelvis, a very shallow acetabulum and a displacement of a poorly developed head and neck of the femur upward and backward. There was no evidence of a secondary acetabulum.

The patient was admitted to the Hospital for the Ruptured and Crippled December 12, 1924, and fifteen pounds of traction applied to the left lower extremity.

Notation of December 23, 1924: A recent roentgenogram taken with the traction in place shows definite improvement, so that the head of the femur is observed to be opposite the upper rim of the acetabulum. Traction is to be increased to twenty pounds.

FIG. 2

Roentgenograph taken 10 months following the operation.

Notation of December 31, 1924: No change noted in a more recent roentgenograph. Operation advised.

On January 2, 1925, the hip joint was exposed through an antero-lateral incision extending downward from the anterior superior spine to below the level of the lesser trochanter. The capsule was incised and a small conical head was brought into view. With the aid of the Doyen reamer, a new acetabulum was formed in the upper half of the old shallow acetabulum. The femoral head was reshaped by removing the irregular portions in the neighborhood of the epiphyseal region, and the newly formed head was then placed in its new position. The limb could be brought down to a straight line

with the body, without redislocating the head. The wound was sewed in layers using chromic catgut for the deeper structures, and plain catgut for the subcutaneous tissues and the skin. No drains were inserted. Long plaster-of-Paris spica bandage was applied from the toes to the nipple line with the extremity abducted and internally rotated. Patient returned to the ward in good condition.

Notation of January 8, 1925: Postoperative reaction has been rather mild. The temperature is within normal limits. Roentgenogram shows the head of the femur to be in the newly formed acetabulum.

Notation of February 5, 1925 (33rd postoperative day): Plaster to be bivalved and the extremity is to be massaged daily, followed by gentle passive motion.

Notation of February 17, 1925: Since the last note the plaster spica bandage has been removed and the patient is now able to voluntarily flex the hip for 10 degrees. Passively flexion is possible to 20 degrees and rotation to either side for 10 degrees. Patient to be allowed up and about with the aid of crutches.

Notation of March 3, 1925 (59th postoperative day): Patient is able to get about for short distances without support. To be allowed to go home.

Notation of August 15, 1925: Since discharge from the hospital and until recently the patient has been receiving physiotherapy. Mensuration revealed one inch of shortening and a range of flexion of the hip of 55 degrees. Abduction is possible to 10 degrees and internal rotation to 15 degrees. The gait is much improved.

Roentgenogram of October, 1925, reveals a well formed acetabulum that is much deeper and larger than that made at the time of operation. The patient clinically is much improved: the gait is better, there is an absence of the origi-

FIG. 3

Range of abduction 10 months after the operation.

FIG. 4

Range of flexion following the operation.

nal lordosis, she is able to stand on the operative side without presenting a lowering of the gluteal fold of the unaffected hip, the range of motion is increasing and the limb is one and one-fourth inches longer than prior to operation. Re-examination December 22, 1925, or approximately one year after operative intervention, discloses similar findings. The result is to be considered a very satisfactory one.

THE OPEN OPERATION FOR CONGENITAL DISLOCATION OF THE HIP: SPECIAL REFERENCE TO RESULTS*

BY HERBERT P. H. GALLOWAY, M.D., C.M., F.A.C.S., WINNIPEG, MAN.

In June, 1920, I presented before the American Orthopaedic Association an impartial review of my results in fifty open operations which I had personally performed for congenital dislocation of the hip. For various reasons which were explained in the paper, twelve of these operations were excluded from the final analysis. This left a total of thirty-eight open operations, performed upon thirty-one patients, and the results were classified as follows: cured, twelve; good results, fourteen; failures, six; doubtful, six; total, thirty-eight. In the cases classified as doubtful, sufficient time had not elapsed since operation to permit the final outcome to be definitely determined. The subsequent history of these doubtful cases justified the forecast I made: There were four cures, one good result, and one failure. This brings the figures in these thirty-eight operations to the following finality: cured, sixteen; good results, fifteen; failures, seven; total, thirty-eight.

It was suggested in the paper that as a result of the experience already gained, future cases would show a larger percentage of cures; for it must not be forgotten that, even yet, comparatively few surgeons perform the open operation, and still fewer have had any extended experience with it; consequently, there have been practically no teachers of the open operation from whom one could learn, and each operator has been more or less of a pioneer. In my own work in this field, aside from what I have been able to gather from reading, my only teacher has been my own gradually increasing experience, and naturally results have improved as experience accumulated.

The advantage of enlarged experience is well illustrated by certain facts. For instance, whereas I formerly advised the operation with misgiving in children past five or six, and frequently refused to operate in adolescents or adults, today I believe that by some form of operation substantial functional improvement can be secured in practically every case and at any age. Further, whereas in June, 1920, I described two paths of approach to the dislocated hip, the anterior and the posterior, in a second paper published in November, 1923, it was stated that both these exposures had been abandoned in favor of the Smith-Petersen approach to the hip; during the past five years I have employed this approach exclusively. In my 1923 paper the following statement occurred: "Since that time (June, 1920) the operation has been further developed and

*Read before the American Orthopaedic Association, Atlanta, April 27, 1926.

improved, until now the results *in young children* are so uniformly satisfactory that one no longer approaches these cases with a feeling of dread or uncertainty, but with confidence that the treatment is simple, safe and practically certain to result satisfactorily. . . . Let it be clearly understood however, that my claim that the open operation is simple, safe and reliable, applies particularly to children under three years of age, who have never been subjected to treatment by manipulation or otherwise." The procedure described in this second paper represents a standardized operation for congenital dislocation of the hip in young children, and the details of operation have remained practically unchanged during the past five years. One detail of this operation, which I inadvertently omitted from my 1923 paper is this: In children past three, and occasionally even in younger patients, after opening the capsule freely and dividing the constricted part, the finger in the acetabulum detects this cavity more or less occupied by a kind of fibrous mass, part of which represents the remains of the ligamentum teres. When this condition is encountered, I introduce my left index finger and pass the convex side of a shallow gouge along its palmar surface into the acetabulum, and with a kind of combined pushing and leverage motion strip this mass from the roof and walls, and push it towards the floor of the socket, taking the greatest care not to wound the cartilaginous lining; the left index finger all the time guiding and controlling the edge of the instrument.

In operating upon certain of the older patients the degree of difficulty experienced varies incredibly. Very exceptionally, in a child of ten or twelve reduction may be effected almost as easily as in the child of three.

FIG. 1

FIG. 2

FIG. 3

FIG. 4

W. H. Congenital dislocation left hip treated by open operation at age of four years. Reduction was easy, but roof of acetabulum was found so shallow that redislocation occurred immediately, therefore, before closing wound a curved gouge was driven in above the roof which was then levered downward and held in its improved position by wedges of beef bone. Pictures show functional result two years after operation. See Figs. 5, 6, 7.

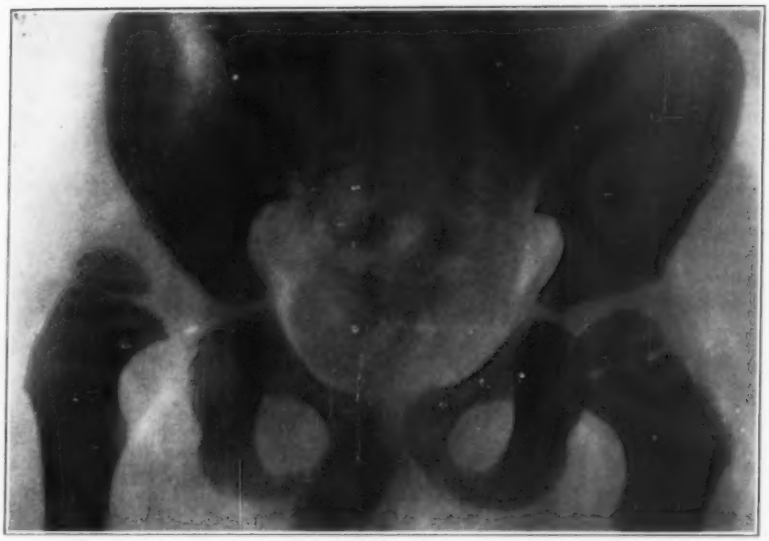


FIG. 5

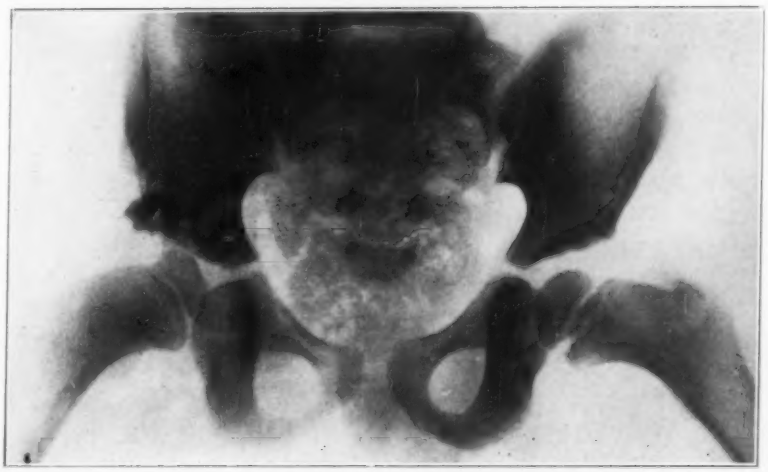


FIG. 6

FIG. 7

X-ray pictures of case shown in Figs. 1, 2, 3, 4. Fig. 5. Before operation. Fig. 6. Two months after operation. Fig. 7. Two years after operation. In this case the acetabulum was found so shallow that its roof was wedged downward as described in the text.

I had an experience of this kind three years ago in Los Angeles when operating upon a patient of ten years, in the clinic of Dr. C. LeRoy Lowman. Reduction was easy, and in a recent communication Dr. Lowman reports an excellent functional result, the boy having flexion to one hundred degrees, and normal adduction, abduction, and internal and external rotation.

In adolescents and adults where I formerly used to do an arthrodesis I now do either the operation of turning down a layer of bone from the ilium and wedging it so as to form a roof over the head of the femur, as so ably described by Dr. Frank D. Dickson, or else with gouge and reamer create a new acetabulum, and the functional improvement is often highly gratifying. While I am inclined to think Dr. Dickson's method has solved the problem of the best treatment for congenital dislocation of the hip in adults, I desire to develop further experience with the creation of a new acetabulum before committing myself to a final opinion, because the results in a few cases where I have made a new acetabulum in the solid bone have exceeded my expectations. In two or three young children where the acetabulum has been found so shallow or its roof so sloping as to make success improbable, I have driven a wide curved chisel almost horizontally into the ilium just above the acetabulum, and after prying down the roof of bone thus loosened, have put in small wedges of beef bone or chips taken from the ilium. The same procedure has been adopted with complete success at a second operation in three or four cases where this condition of the acetabulum has caused the replaced hip to become redislocated. (Figs. 5 and 6, and 29 and 30.)

Since my 1920 paper was presented, I have operated on thirty-eight hips in thirty-four patients. It was only on going carefully through my

FIG. 8 FIG. 9 FIG. 10 FIG. 11

B. K. Congenital dislocation right hip treated by open operation at age of two and a half years. Functional result at five years. See Figs. 12, 13, 14, 15.

FIG. 12

FIG. 13

FIG. 14

FIG. 15

X-ray pictures of case shown in Figs. 8, 9, 10, 11. Fig. 12. Before operation. Fig. 13. Four months after operation. Fig. 14. Nineteen months after operation. Fig. 15. Two and one-half years after operation. Note appearance of head at different stages.

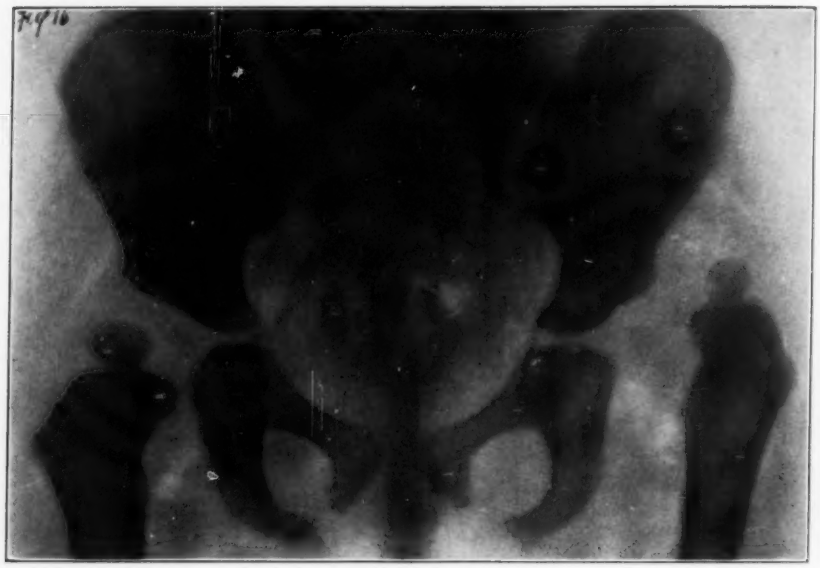


FIG. 16

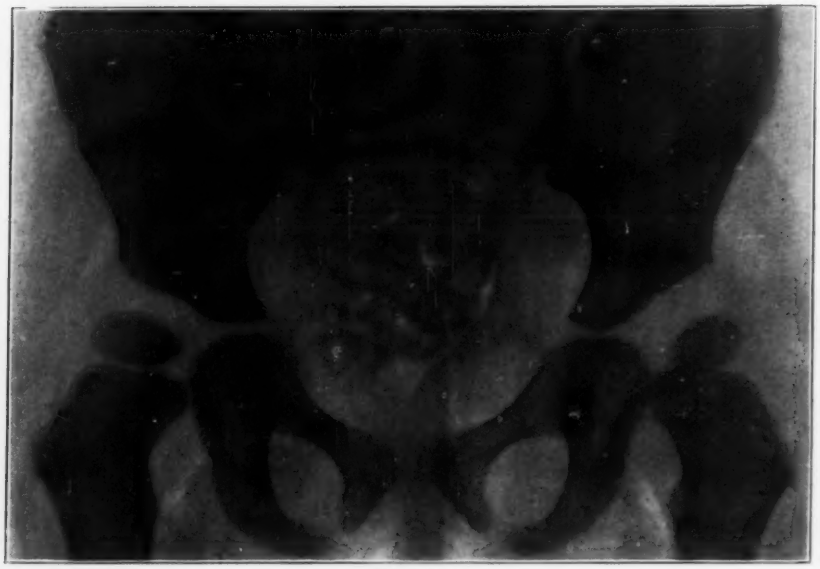


FIG. 17

Grace C. Open reduction at twenty-five months. Appearance of joint before operation and one year later.

records in preparation for this present paper that I discovered the curious coincidence that this second series is exactly the same in number as those included in the final analysis in my 1920 paper. Adopting the same classification as in the 1920 paper, the results stand as follows: cured,

fifteen; good results, eighteen; doubtful, five; known failures, none. Some comment on each of these groups is called for. In those classified as "cured" a severely high standard has been set. The functional result in the cases included in this group is such that the hips are almost if not quite perfect in every way; in unilateral cases one hip is practically indistinguishable from the other. In a small proportion there is a remnant of functional imperfection, so slight as to be of no consequence, and only critical observation could detect it. It is noteworthy that with the exception of one child of four years, the oldest child in this group was two and a half at the time of operation, and the youngest seventeen months; further, none of them had been subjected to previous attempts at manipulative reduction. For years I have combated the common teaching that the open operation should be reserved for cases where the manipulative method had failed. I cannot emphasize too strongly my belief that the ideal age for the open operation, as I perform it, is from twenty months to two years, and that the disturbance of the tissues by previous unsuccessful manipulative efforts renders the complete success of the open operation much more doubtful. Let me state deliberately that the open operation as it is done in my clinic, when performed on children of about two years of age who have not been previously manipulated, is as free from risk, and has become as certain in results as my operations for club-foot, bow-legs or knock-knees.

Of the cases classified as "good results," the youngest patient was three years and nine months, the oldest twenty-nine years. In two of

FIG. 18

FIG. 19

FIG. 20

Jean G. Double congenital dislocation. Open operation at four years but no acetabulum was found on either side. Eight years later one hip was reopened and a new acetabulum formed in the solid bone. The following year this was repeated on the other side. The pictures show the amount of movement. See Figs. 21, 22, 23.

FIG. 21

FIG. 22

FIG. 23

X-rays of Jean G., before operation, after operation on first hip, and after operation on second hip. See Figs. 18, 19, 20.

them, which belonged to the earlier cases of the series covered by this report, arthrodesis was performed. In two other adults, one of twenty-five and one of twenty-nine, Dickson's operation was performed. In one a triangular acetabulum was considerably excavated at its upper part. In one of the cases of this group, a physician's daughter twelve years of age with double congenital dislocation, I had attempted reduction by the open method when the child was four years old, but was unable to find an acetabulum on either side. The x-ray taken eight years later suggested a shallow acetabulum, but on opening one side nothing but a slight depression could be found. An excavation with gouge and reamer was made, and the head implanted in this new socket. I expected failure, but the result was such that the child's father was more than willing to have the same operation tried on the other side the following year. Creation of a new acetabulum was again necessary, and equal success was achieved. The photographs and x-ray pictures of this case are herewith reproduced. (Figs. 18, 19, 20, 21, 22, 23.) In all cases of this group the functional improvement is pronounced and unmistakable; but because of limitation of motion, slight shortening, or deformity of the head or acetabulum, there is a remnant of lameness or other functional disability. In some cases the defect is so small as to be almost negligible; in others it is of greater consequence. The least satisfactory case functionally of this group is that just described, and illustrated in Figures 18 to 23.

Of the four cases classified as "doubtful," one was a Japanese child, three years old, where, although reduction had been easy, the acetabulum was so unsatisfactory that the reduction could be maintained only with the hip in wide abduction. Fourteen months later the child had a very slight

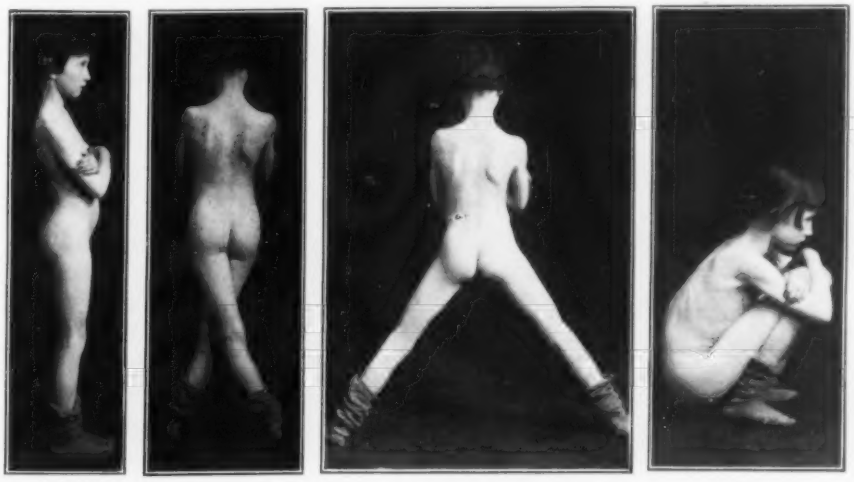


FIG. 24 FIG. 25 FIG. 26 FIG. 27

Congenital dislocation both hips. Left hip reduced by open operation September 9, 1919; right reduced January 24, 1920. These photos were taken April 3, 1926,—more than six years after operation. See Fig. 28.

FIG. 28

X-ray of case shown in Figs. 24, 25, 26, 27. Left hip operated on September 9, 1919; right hip on January 24, 1920. This picture shows the appearance of both joints on April 3, 1926—more than six years after open operation.

limp, but the affected limb was slightly longer than the other. An x-ray picture showed the head unusually large, and while a picture taken in internal rotation showed good stability, one taken with the hip externally rotated showed a precarious relation of the head to the acetabulum. In this case I expected later to have to correct the sloping roof of the acetabulum, by wedging it downwards in the manner already described, but I have been unable to trace the patient since August, 1924. Of the three other doubtful cases, one is a young child, where a perfect cure was secured on one side, but the other hip had become redislocated; I am confident that in this case a good result will be secured later, by wedging down the roof of the acetabulum. Another of these cases has been operated upon too recently to permit any opinion as to the final outcome. Another is a patient of five years who was kindly referred to me by Dr. Geist of Minneapolis. In this case, previous manipulative reduction had failed in both hips. On one side, I secured a hip which is included in the group of good results. In the other, the head is firmly in the acetabulum, but there is more limitation of movement than usual, and the final outcome as regards function is still somewhat in doubt, although my belief is that ultimately it will be fairly classed as a good result, and Dr. Geist is of the same opinion. Another of the doubtful cases is one which I operated on in Dr. F. C. Kidner's clinic in Detroit. The hip is in position but the child has developed pulmonary tuberculosis and a middle ear infection, and is in poor general condition. Physiotherapy has been less satisfactory than in similar healthy cases and there is considerable limitation of movement.

FIG. 29

FIG. 30

Clara K. Open operation at two and a half years. Hip became redislocated owing to shallowness of acetabulum. Fig. 29 shows hip eighteen months after first operation. Fig. 30 shows hip five weeks after second operation. Note improvement of acetabulum produced by wedging down its roof, as described in the text.

There are no known complete failures in this last group of thirty-eight cases, and I am confident that the subsequent history will show most if not all of the five herein classified as doubtful to be either cured or to belong to the group of good results.

I am not advocating the adoption of the open operation by those who feel satisfied with the results they obtain by manipulation. Personally, I was driven to the open method by the distracting uncertainty and frequent failure which attended my former efforts at manipulative cure, and my results are now such that I welcome these cases instead of dreading them as I once did. I think I am justified in claiming that a method which will cure practically all children of about two years, and which has given such a large proportion of good results in patients varying from seventeen months to twenty-nine years, at least should not be entirely discredited.

CONGENITAL DISLOCATION OF THE HIP

A Report of Three Hundred and Ten Cases Treated at New York Orthopaedic Dispensary and Hospital *

BY BENJAMIN P. FARRELL, M.D., HERMAN L. VON LACKUM, M.D., ALAN DE F. SMITH, M.D., NEW YORK

This is a final report of 310 cases of congenital dislocation of the hip treated at the New York Orthopaedic Dispensary and Hospital from October, 1900, to October, 1920. The most recent case of the series was treated more than five years ago. In eighty-five patients the condition was bilateral, making, therefore, a total of 395 hips. This number includes all of the patients treated at the clinic during the twenty-year period with the exception of one or two whose records were lost. In no sense have the cases for the report been selected. Of the 310 patients, 266 were followed for a period long enough to determine the end result. The remaining 44 were reduced but disappeared within a few months after the initial treatment. They are therefore excluded from this study which deals with the 266 cases and 336 hips, the final result of which definitely is known. In all of these cases some method of closed reduction was attempted. The Hibbs table was employed in the majority; manipulation by circumduction and without the use of apparatus was used in many cases; and in six the Lorenz method was tried. Four cases in which the closed method failed were reduced by open operation. It is now our custom to resort to this in a much larger proportion of cases.

Of the 266, including 196 single and 70 double cases, that were traced to a conclusion, one or both hips remained in the acetabulum with a good functional result in only 103 cases, or 39 per cent. However, among the 61 per cent. that did not remain in place, were 40 cases, or 15 per cent., in anterior transposition, stable and with only slight shortening, which were counted as fairly good functional results. This raises the proportion of good functional results to 54 per cent. of the cases. Considering the results from the standpoint of the number of hips treated, rather than cases, 139 of 336 remained in place, or 41 per cent. In 196 single cases 84 or 43 per cent. were permanently reduced with good function. In 24 additional cases, or 12 per cent., there was good function in the anterior transposed position, making in all 55 per cent. of good and fairly good results and 45 per cent. of failures. In only 27 per cent. of the double cases was a permanent reduction of both hips obtained, but 23 per cent. were good functionally so that the total percentage of fair functional results was 50. Seventeen cases, including 24 hips, and comprising 5 per cent. of the total number of cases could not be reduced at all.

* Read before the American Orthopaedic Association, April 27, 1926.

The double cases numbered 85, or 27 per cent. of the total, and there were thus 225 single cases, or 73 per cent. Two hundred and sixty-four cases, 85.2 per cent., of the patients were females and 46 cases, 14.8 per cent., males. In 79 cases or 35 per cent. of the 225 single hips the right side was involved and in 146 cases or 65 per cent., the left. The age on admission in 216 hips, or 55 per cent., was under five years; between five and six, 81 cases or 20 per cent.; between seven and eight, 52 cases or 13 per cent.; over eight years, 12 per cent.

The importance of the age of the patient at the time of reduction is brought out very forcibly in an analysis of the results according to age groups. In the first, including those cases under five years, 53 per cent. were reduced and had a good result as compared with 39 per cent. in the entire series. In the second group, those at five and six years, 43 per cent. were reduced with a final good result. Only 23 per cent. of such results were had in the seven- and eight-year period, whereas, curiously, those over eight years presented 32 per cent. of reductions. The importance of instituting treatment at an early age does not need to be advocated before this society, but we feel very strongly that more careful training of medical students is necessary in order to make this possible in the future. We also urge that the routine examination of all infants at birth include that for congenital dislocation of the hip. Although we rarely see a case under one year of age, we advise attempting reduction at once, regardless of how young the patient may be.

It was expected that a careful study of the double cases, especially those in which one hip remained in place and the other did not, would be illuminating in pointing out the important factors in the failures, but this was not the case. The complete number of double cases was 85, of which 70 were followed. Both hips were reduced and remained in place in 19 cases, constituting 27 per cent. A successful reduction was done in both hips of seven other cases which could not be traced. In 25 others, one hip was reduced but the other came out. Seventeen of these were followed to an end result. It appeared that in these cases the anteversion of the femoral neck was greater on the dislocated side in 5, and that the acetabulum was more imperfect in the same number. These 17 cases with unilateral reduction are 24 per cent. of the 70 cases of which we have a satisfactory record. In 6 of these, or about one-third, the dislocated hip was in the anterior position and quite stable, the result as a whole being fairly good. Among the 34 cases, or 48 per cent., of double hips in which neither one stayed reduced, were 10 with good stability in the anterior position. The total per cent. of good functional results due to this factor in the bilateral cases is 23, which added to the 27 per cent. of good anatomical and functional results gives 50 per cent. Six of the double cases could not be reduced at all.

The Hibbs table was used first in 1906 and since that time has been employed in all of the more difficult cases and in many of the others. It has been fully described but we wish to reiterate that the basic principle in its

use is manipulation by flexion and adduction in order to bring the head of the femur below the acetabulum, followed by abduction and extension. At this stage of the maneuver, a pad is utilized, not to make pressure against the head, but by impinging upon the trochanter to guide the head into the acetabulum. The apparatus in no way increases the force used, but on the contrary prevents pressure on the head by transferring it to the trochanter.

About two-thirds of the hips were treated by means of the Hibbs table and about two-thirds of these cases resulted in failure. About half of the cases treated by manipulation without the use of the table were successful. These were the easy cases in young children, which in all probability accounts for the better results. Of the twenty-three cases which could not be reduced at all, nineteen were treated on the table and four by manipulation. Six cases and eight hips were manipulated by the Lorenz method. Six were successful and two failed.

Among the successful cases, nineteen, of which two were bilateral, were subjected to a second reduction; thirteen cases, including two double dislocations, were reduced a third time; two cases, one single and one double, a fourth time and one double case, in which the result was one reduction and one failure, was attempted five times.

Torsion of the shaft of the femur causing anteversion of the neck of more than twenty degrees was present in 188 hips or 47 per cent. of the series. We consider that any degree of anteversion up to twenty is within normal limits. It is our opinion that this condition is of great consequence in congenital dislocations, and that it is one of the prime factors producing dislocation as well as causing the dislocation to recur after reduction. It does so obviously by making the head of the femur protrude from the anterior part of the acetabulum. In our experience at this clinic it is difficult to estimate accurately the degree of anteversion. Almost invariably two or more surgeons will make a different estimate of any one case, though there is no marked difference of opinion. In order to assist in determining this point, the x-rays of our congenital hips always are taken in two positions, both antero-posterior and in the neutral position of rotation and the second with the femur rotated inward to the greatest possible extent.

The degree of anteversion was estimated at more than fifty degrees in 96 cases and between twenty and fifty degrees in 92 cases. In those with less than fifty degrees, fifty per cent. stayed in place after reduction and fifty per cent. did not. Of the 96 cases with more than fifty degrees anteversion only thirty per cent. were successful and seventy per cent. were not. An attempt was made to correct the anteversion by osteotomy in thirty-five cases. Thirteen of them subsequently remained in place and twenty-two did not. Among the latter, however, were many in which the osteotomy was unsuccessful and in which a considerable degree of anteversion remained. We believe that this does not constitute an argument against performing this operation but that it should caution us

to use greater care in doing it. Ordinarily it should not be done until after the hip has been reduced, because it does not make the reduction more difficult but diminishes the chance of success afterwards. Naturally correction of the anteversion would be of no value if the hip could not be reduced. It should be noted that osteotomy should not be performed in those cases in which the femur cannot be internally rotated.

The number of cases in which reduction could not be effected at all was twenty-three, twelve double and eleven single, or thirty-five hips, seven per cent. of the whole number. The majority of these were among the older cases which probably was an important cause. In practically all of them the acetabulum was deficient or the head and neck were abnormal. Most of them exhibited considerable stability and a lack of flexibility with difficulty in getting the head below the acetabulum. All but two were dislocated high above the acetabulum. Anteversion was present in all. Because none of these patients was subjected to open operation the actual conditions are unknown. Judging from our experience in cases operated on subsequently, we believe that in a number of these cases, as in other similar ones, the cotyloid ligament must have been contracted to such an extent as to prevent the entrance of the head into the acetabulum.

Only four cases of the entire series were subjected to open operation. All were reduced and are stable. Limitation of motion ensued in three, in one to a marked degree; one moderate and one slight. In the fourth, motion was free. All definitely were improved by the operation. It is now the custom in this clinic to resort to open operation in a much larger proportion of the cases. The end results in these have not yet been studied but will be reported later. In many of these cases the cotyloid ligament was contracted over the entrance to the acetabulum, forming an impassable barrier to the head. These were the cases that could not be reduced. In others in which the dislocation recurred a deficient acetabular roof was a frequent finding. Although in practically all a permanent reduction resulted, limitation of motion frequently has been present.

A perfect anatomical result judged by the x-ray, by which is meant no appreciable difference on the dislocated and normal side, was found in only seven cases. In the others a greater or lesser degree of irregularity of the acetabulum with deficient roof, flattening, mushrooming or fragmentation of the head of the femur or atrophy of the head and neck were encountered. The functional result usually was better than could be expected from the x-ray. It seemed impossible to judge the depth of the acetabulum from the x-ray because in the younger children so much of the wall is not yet ossified.

Several factors have received careful consideration in the endeavor to give a prognosis in any given case. First is that of age which requires no further comment. We stress a number of points in the physical examination. Of importance is the mobility of the hip and particularly the ability to bring the head below the acetabulum by flexion of the thigh. Tenseness

of the muscles and considerable stability in the dislocated position often forecast difficulty in reduction. An abnormal degree of anteversion is very important. If this is associated with limitation of internal rotation it usually means not only instability after reduction but a serious obstacle to reduction. If anteversion is present and the hip well reduced the prognosis should be good, provided the anteversion is corrected. The appearance of a shallow acetabulum in the x-ray in a young child considered alone has little significance. In a hip that is very unstable after reduction it has much. If the head apparently goes into the acetabulum easily but is very unstable and the postoperative x-ray shows the head opposite the acetabulum but not really socketed in it, the prognosis is very doubtful. It is in such cases that we are inclined at once to advise open operation. They are the ones with contracture of the cotyloid ligament. If, however, after such a reduction the x-ray indicates that the head really is in, the result may be a very stable hip. The procedure in the doubtful cases now is to leave them in plaster for several months. If at the first change they redislocate they may be tried again and if that attempt fails, operation is advised.

After reduction the hips were immobilized in a plaster spica in the position in which they seemed most stable. This usually was in from sixty to ninety degrees abduction. In those with marked anteversion the femur was rotated inward as far as possible. The period in plaster casts varied from one and a half to fifteen months. The average time in the successful cases was about five months and in the unsuccessful ones about six months. We believe that prolonged immobilization is unnecessary in the stable cases and that in most of the others it accomplishes little. There were more successful cases among those immobilized for three months than among those for nine. The patients were allowed to walk in plaster as soon as the abduction could be decreased sufficiently, on an average of three months. Most of the cases had massage and passive motion after the plaster cast was removed. We believe that this did not accelerate the recovery of mobility appreciably.

After the discovery of the number of our failures the task of second importance is the analysis of the causes. One which suggests itself at once is a lack of expertness on the part of the operators. This is a difficult question for us to pass upon. We may say, however, that the first 200 cases of the series practically all were treated by the senior members of the attending staff, as were the majority of the others, including all of the difficult ones. It also develops that the results in the later cases are no better than in the earlier ones. In brief we may recapitulate that the most important reasons appear to be age, anteversion not corrected, bony abnormality of the acetabulum and head and neck of the femur and contracture of the cotyloid ligament rather than of the capsule. We think it fair to say that these factors are such that it can scarcely be hoped to overcome them by any method of closed reduction and that persistent attempts to do so would result only in traumatism.

CONCLUSIONS

1. In any large series of cases of congenital dislocation of the hip as now seen, success by closed reduction can be expected in only about fifty per cent.

2. These results could be improved upon if more of the cases were treated early, and every effort should be made to bring this about.

3. The other factors chiefly responsible for the failures are such that we cannot hope to overcome them by any method of closed reduction.

4. In many cases the presence of these factors can be suspected but can be determined definitely only by open operation.

5. The number of open reductions in this series is too small to justify any general conclusions. We are not yet prepared to announce the results in a larger subsequent series, but we are quite certain that many of these cases, although reduced and stable, have a considerable degree of limitation of motion which has been present for a number of months.

6. We believe that practically every congenital dislocation of the hip within a reasonable age limit can be reduced by open operation and in that way improved.

7. The results in this series of cases compel us to believe that a much larger percentage should be reduced by open operation than were so treated.

NOTE: A paper presented at the same session by Dr. DeForest P. Willard on "End Results of Davis Manipulation in Congenital Dislocation of the Hip" will appear in the next issue of the *Journal*.—*Editor*.

DISCUSSION

DR. Z. B. ADAMS, Boston, Mass.: Dr. Galloway in his paper did not make it clear to me exactly why he thought previous manipulation increased the risk of operating later. It seemed to be the opinions of the readers who followed Dr. Galloway that it would be perfectly safe to make an attempt manually or by closed methods to reduce and then failing in that to do an open operation.

The question of torsion,—Dr. Farrell and Dr. Willard both had something to say about torsion and I agree with Dr. Farrell that it is a frequent obstacle to maintaining the reduction and that we should in the future pay much more attention to the question of torsion. I do not see how with an increase of torsion over twenty degrees, as Dr. Farrell shows, the hip can be expected to stay in. I think it will lever itself over into a marginal position or lever itself out. In one of the cases Dr. Galloway showed the hips had been allowed to stay on the dorsum of the ilium and he showed a moving picture of that girl with a very hollow back. I think we should if possible try to get the hips forward so as to reduce the hollow back, for that is a distinct failure because a hollow backed person cannot carry on with pain.

As to deformities of the head and neck, I used to feel they were due to trauma at the time of reduction. Now I am not sure.

Another point is the value of exercise. A you know, I went over and saw Professor Denucé and I feel very sure that he was honest and his results were what he said they were. My experience with his method has not been as good as his results. I have not been as successful in getting some of the hips in with that method. Possibly I do not know how, but with greater experience I feel that there are decided obstacles to reducing some of these hips and Dr. Farrell has mentioned some of these obstacles

—either the acetabular and capsulary ligaments have been narrowed so the head cannot go into the socket or else there is a roll of the anterior part of the capsule which gets into the socket before the head. Those obstacles must be eliminated by open operation or the head will not go into or stay in the socket.

I want to ask Dr. Farrell why he said the head could not be inwardly rotated or the thigh could not be inwardly rotated. He did not give any reason but stated that as one of the reasons against the possibilities of reduction.

Dr. Robert Soutter, Boston, Mass.: There are a number of things that have been brought out by these papers. It seems to me that if we are going to get anywhere with our problems, we should divide our cases into groups according to their problem and take each group and decide which one gives the largest percentage of cures and also what we should do with each one.

The most serious problem in congenital dislocation of the hip is the irreducible case in which it is impossible ever to make the head reach the acetabulum.

Next in importance are the reducible cases with the following difficulties:—

First. The case in which the head must travel far to reach the acetabulum.

Second. The case in which the head is not far off but the toughness of the soft parts makes it difficult for the head to reach the acetabulum.

Third. The case in which there is definite obstruction at the mouth of the acetabulum, either due to the rim or the capsule.

Fourth. The case with bony defect and which makes the reduction less stable.

Fifth. The cases of young children who have walked but a short time, whose tissues are soft and pliable.

There is an erroneous idea that any one can attempt a bloodless hip reduction whether he is skilled or not and do no harm.

There is also an erroneous idea that an open operation is harmful.

Both operations may be productive of harm in the hands of the unskilled.

I have used the closed method and have had experience with the open operation in my own cases and in assisting Dr. Bradford, when for many years he was using the open method. Dr. Sherman became enthusiastic over the method which Dr. Bradford was using and I have discussed it with him many times.

Before going further, I want to compliment Dr. Galloway, Dr. Willard and Dr. Farrell on their cases. Dr. Galloway, besides the fine work he has done in small children, has emphasized a very important point and that is that the open method should not be undertaken by the inexperienced and that it should be done only by a highly trained surgeon familiar with such operations.

When a surgeon has learned the open method from a competent man and is himself a trained surgeon, such a man may reduce cases, preferably under three years old, and expect in six months to have the child walking and the percentage of cures will be very high. This is practically what is claimed for the open method. The enthusiastic advocates for the open method claim this and to the closed method they sometimes attribute all the accidents that are possible to cases of all ages and cases of varying difficulty. This is not at all a fair method of comparison. If, in the open operation, cases of three years and under are the subject of our theme, let us likewise limit the age in bloodless reduction to cases of three years and under. The hazards of the bloodless method, such as peripheral nerve injury, occur at most in two per cent. of 3176 cases from thirteen European clinics. It does not occur in children under four years old, unless the head has to travel some distance to the acetabulum which is rare at this age; and when the distance is great in older subjects, the stretch on the nerve will be the same whatever method is used.

I have found reduction by the closed method, in children under four, to be safe and satisfactory, provided the surgeon familiarizes himself with the method and is taught the technique by one skilled in its use. The operation should be undertaken only by a surgeon thoroughly trained in the method.

There is a slight knack in the reduction of a congenital dislocation of the hip but

it may be taught. The surgeon should not only learn both methods but know when a hip is satisfactorily reduced by the closed method. A satisfactory reduction implies that the head is felt to be firmly engaged in the socket and when so engaged it should be possible to flex the femur ninety degrees and abduct it ninety degrees so that the leg will lie in the frontal plane of the body. After reduction, the hip must be manipulated so that the head may be felt to click or jump in when reduced and to click or jump out when redislocated. This may be accomplished in a large majority of the cases and in practically all small children. When this cannot be accomplished, the head has not been satisfactorily reduced, even though the x-ray shows it in good position. We should not wait for time to complete the reduction by pressure in this type of case. An open operation should be done, the capsule divided and the head can be reduced readily. I feel that the position of the hip after operation should be used not to aid a partially reduced hip but to allow the soft parts to shrink.

The reduction of a congenital dislocation of the hip by the bloodless method in which the surgeon has not acquired proficiency, will necessarily bring discredit on the method. A surgeon who is not skilled in surgical technique will likewise bring discredit on the open method.

Both methods will be found to be safe, reliable and satisfactory in children under four, excepting where the acetabular roof or shelf is very defective and this cannot readily be determined in x-rays of children under three.

The surgeon may choose the method he prefers. In small children the indication for an open operation is that the surgeon must be highly skilled in surgical technique and know what he is planning to do and be able to reduce congenital hips. For the closed method, the surgeon must also be highly skilled in the method and know what he is planning to do and be able to reduce congenital hips.

In children under four, a highly trained surgeon, familiar with such operations, will not find a disturbing uncertainty attending the operation or the after treatment; either method will be safe and reliable in his hands.

When parents are taught to bring us their children before three years old, our problems of reduction will be simple.

We are all familiar with the lamentable results of club foot operations done at large by the open and by the closed method. Satisfactory results are possible by both methods in the hands of a highly trained and experienced surgeon who will understand what to do and what to expect by the open and closed methods. Such a surgeon plans an open operation deliberately and may use either method when necessary.

If we are to have good treatment in congenital dislocation of the hip we must be as skilled in handling these cases as we are in handling club feet. We must have learned the method and know what we dare do with a reasonable degree of safety. The problem is not difficult in the small flexible hip or the small flexible club foot. The difficult cases are those that need our skill and judgment. Our real difficulties are from the older cases and open operation alone will not solve all our problems, neither will the closed. In some cases both methods will fail to solve the problem.

If I should make a short resumé of the cases treated at the Children's Hospital, Boston, in quoting from a report on 355 operations, with adequate operation and after-care, from 80 to 90 per cent. of all hips seen before the seventh year ought to be permanently reduced with good function.

There was 71 per cent. of success if all cases are counted and the forty-two unknown ones counted as failures (which was not the case); but of the cases personally examined in which the result was known, the percentage of success was 83.8.

I believe that in children under four, where the surgeon has complete control of the after-treatment of the case, the percentage of cures should be over 95 per cent.

Dr. Frank D. Dickson, Kansas City, Mo.: So much has been said about congenital hip that I suppose you do not want to hear much from me. I had the privilege of seeing Dr. Galloway do two hips in Detroit last December and can testify to the ease with which he puts these hips in. My experience tells me the same thing, that the

open operation is a comparatively simple procedure in the hands of an experienced operator. It has one big advantage over the closed method—it enables you to remove any obstruction to reduction of the hip and at the same time to ascertain the condition of the head which the closed method does not. The crux of the situation does not seem to be the method but the age. Dr. Willard has emphasized the age. It was emphasized in Dr. Farrell's paper and Dr. Galloway's slides showed very conclusively that his best results were in the early cases. Therefore, the basis of successful reduction is to get your cases as early as possible,—anywhere over a year. I have not recently had a bad result in a case under two years.

I agree with Dr. Galloway that there is no reason why the open operation if it is a good operation should not be used at any age and not restricted to older cases. On the other hand, I do believe that by closed manipulation we can reduce practically every hip at an early age without subjecting them to trauma. However, the moment we learn to reduce hips at three and four by the open method, I believe we will get better results, leaving out the small percentage of congenital defects or deficiencies which we cannot control.

I do believe that the open method is a good method at any age. I believe it is the only method after four or possibly three years of age, because you can get your hip in with less trauma and less danger of bad after-effects and get a more rapid convalescence. As in all surgical procedures where there are two procedures available which are equally good, it is a question of experience and judgment which should be used in any given case.

Dr. F. C. Kidner, Detroit, Mich.: Dr. Galloway very kindly came a year ago to our Children's Hospital in Detroit and although we gave him children much older than he liked to operate upon, it was apparent to those present that reduction was easy for him. No more effort was put forth than in the simpler closed manipulations. One of the cases was a double dislocation. Dr. Galloway reduced the left hip by his open method and then very kindly allowed me to reduce the right one by a closed method. Both hips were put up in identically the same positions. Today the appearance in the x-ray of the hip reduced by Dr. Galloway more nearly approaches the normal than does that on the side on which I operated by a closed method. Both sides are very close to normal as far as limp and motion are concerned. What difference there is, is in favor of the open operated one. Of course, there are always slight variations between the two hips in the final results of any double cases.

Dr. A. H. Cilley, New York, N. Y.: I want to cite a case of a child ten years of age for whom the mother refused open operation. I stretched the limb to full abduction and much to my surprise the head slipped in as easily as could be. We followed the progress with the x-ray and in the third plaster when the leg was pretty nearly straight the head had slipped to the rim of the acetabulum. We then after much persuasion of the mother were permitted to open the hip. We found on opening it by the Smith-Petersen incision that the head had slipped and was resting on the rim of the socket and the acetabulum was not deep. As long as we had it opened we turned down the superior border of the acetabulum, and put in a couple of chips from the ilium. With the thigh in full internal rotation the head was securely in the acetabulum, so in this position we pushed a drill through the base of the trochanter perpendicularly to the neck and sewed the wound up without drainage. Then we put on plaster over the body and sufficiently far down on the thigh to hold our drill. Then we did an osteotomy and turned the foot out to straight which rotated the lower fragment more than forty-five degrees. The case is still in plaster and is consequently a perfect result. Later we may not be so sure of it.

Dr. J. L. Porter, Chicago, Ill.: One of the great reasons for the early operation has not been brought out, and that is that the dislocated femoral head does not develop, become solid and hold as the head does that is functioning in the acetabulum. The bone becomes not only misshapen in its dislocated position but has a tendency to atrophy. I have reduced one congenital dislocation between the age of twelve and

thirteen years and reduced it so easily that I was surprised. I had had the limb under traction of 20 lbs. three weeks before reduction, which I think was an important factor. I patted myself on the back and thought I had accomplished something. As a matter of fact, that hip went on to complete atrophy, destruction, and became ankylosed, and I wished very much I had let it alone.

Dr. J. T. Rugh, Philadelphia, Pa.: There are two or three points to which I wish to call attention. We have heard them speak about the normal hip. There is no such thing as a normal hip in a congenitally dislocated hip. These hips are abnormal. If they were normal we would have no trouble in reducing them. The tissues always remain subnormal in comparison with those on the other side.

The other point that was mentioned is the use of the x-ray in determining the depth of the acetabulum. To me it is of very little value. All of us who have done this work realize the same thing. We have all seen these cases in which the x-ray shows a very sloping bony shelf and yet at reduction the head has slipped in with a pop that could be heard all over the operating room.

Another point is the difficulty encountered in the reduction of the hip. I agree that we should get them early but we do not always get them early. When we get an older hip that can be drawn down one and one-half to two inches we feel justified in trying reduction of the hip. Under those conditions I always feel much safer in my reduction if I am dealing with a fat child than if I am dealing with a thin one. The muscles in the fat child yield better than those in the thin one as the thin, wiry muscles found in this type are most resistant.

Dr. W. S. Baer, Baltimore, Md.: Being a great advocate of the closed method of operation, I find myself, year by year, going over more and more to the open operation in many cases. I want to state, however, that the operation, to my mind, is not without its dangers. I have had my first sciatic paralysis after performing a reduction by an open operation. I have never had anything of that nature in the closed method.

Dr. Samuel Kleinberg, New York, N. Y.: In reducing these hips in children over three, I have found that cutting the adductor tendons has reduced the trauma and facilitated reduction.

Dr. H. P. H. Galloway, Winnipeg, Canada (closing his part of the discussion): It seems to me that the outstanding fact resulting from this series of papers and the discussions which have followed is that we are making some progress in treating congenital dislocation of the hip by both the open and closed methods. I have not come here to convert any one to the open operation; I am simply speaking of what I have found to be the best method for myself. I would be very proud of a series of results such as Dr. Willard showed. I have never been able to get such results by the closed reduction.

A good deal of emphasis has been laid on the necessity for gentleness. I feel very much indebted to Dr. Kidner for his kind remarks. I think most of those who have seen me do the operation have noticed that the actual traumatism of the operation is less by a well-performed open reduction than by the manipulative method. It is because of the traumatism to the tissues which results from manipulation that I prefer the open method. I prefer to do the open operation as a primary procedure and not after the other method has failed. I am certain that the results are better in the cases in which no manipulative operation has been attempted before the open operation is done.

The question of torsion of the neck of the femur is one which many men have spoken to me about privately. Dr. Farrell spoke of the difficulty of determining the degree of anteflexion. It is curious that this has never become a practical question with me in connection with the open operation. I referred to one case in my paper, a Japanese child, where the relation to the acetabulum was precarious when the limb was externally rotated. I think that was due to anteflexion of the neck. I know Dr. Sherman became a great advocate of osteotomy for anteflexion. It never seemed necessary in any of my cases unless this Japanese child should be one.

One of the great advantages I see in the open operation is that you can determine the exact conditions present. You do not have to guess at the condition of the head or the degree of anteflexion or depth of the acetabulum. I agree with those who said that these things cannot be determined before operation. They can be determined after the hip is opened and then one can act more intelligently.

Dr. De Forest P. Willard, Philadelphia, Pa. (closing his part of the discussion): It seems to me that in this discussion both types of reduction have survived the ordeal, that both manipulation and operation are firmly established as good methods. It also seems to me that both types of operation give by far the best results in younger children. This is especially true of the manipulative type. We all know that a very small percentage of our cases come to us under eighteen months of age. I believe that as a group we can do more both for ourselves and for our patients if we can educate not so much the orthopaedic surgeons but the profession at large to recognize these cases in the early stage and get these cases to us for early treatment. To bring this out perhaps a little more forcibly, I discussed congenital hips with Dr. Putti when he was here last fall. He had read a paper here reporting 2000 cases of congenital hip dislocation which he had attended in the Institute Rizzoli since the war—an enormous number of cases when compared with our clinics in America. The striking thing was that he got his cases early and he has gotten them early because he and his confrères have taken on an educational campaign all through Italy to recognize these cases as soon after birth as possible and get them to operation at the earliest possible moment. If we can do that in this country I believe we will assist ourselves materially in the treatment of congenital hips.

Dr. B. P. Farrell, New York, N. Y. (closing his part of the discussion): Dr. Adams asked about the cases that we cannot internally rotate. I do not know why we cannot, but there are a few that cannot be internally rotated.

Dr. Soutter brings out the fact that it is an erroneous idea that without experience you can do a closed reduction without trauma to the head. I will have to disagree with that because I think even with experience we cannot do a closed reduction without trauma to the head. I think every reduced case has some trauma. I agree with Dr. Galloway that you can do very much less trauma in the open reduction than in the closed reduction. While as yet I have not nerve enough to open every youngster's hip below four years of age, I am not sure that he is not right, and that we are very rapidly coming to it.

OSTEOMATA OF LOWER END OF TIBIA

BY EDWIN WEINBERG, M.D., BALTIMORE, MD.

Louise Bowles Fellow. Children's Hospital School

The x-ray appearance of osteomata as described by Baetjer, is as follows: "They assume a cauliflower shape and are characterized by a large amount of new bone laid down in a symmetrical manner with a very definite border and no evidence of invasion".

They may occur with the bones of the skull, the pelvis, the scapulae and the long bones. The bones of the skull seem to be especially favorable sites. On the long bones they are commonly found at the inner and upper end of the tibia and the inner and lower part of the femur.

They show no tendency to become malignant, nor do they recur after removal. They are of importance because they may prove a block to the movement of a joint, and because of the pressure effects to the overlying skin.

FIG. 1

CASE 1. A. C. Lateral view before operation.

FIG. 2

CASE 1. A. C. Lateral view nine months after operation.

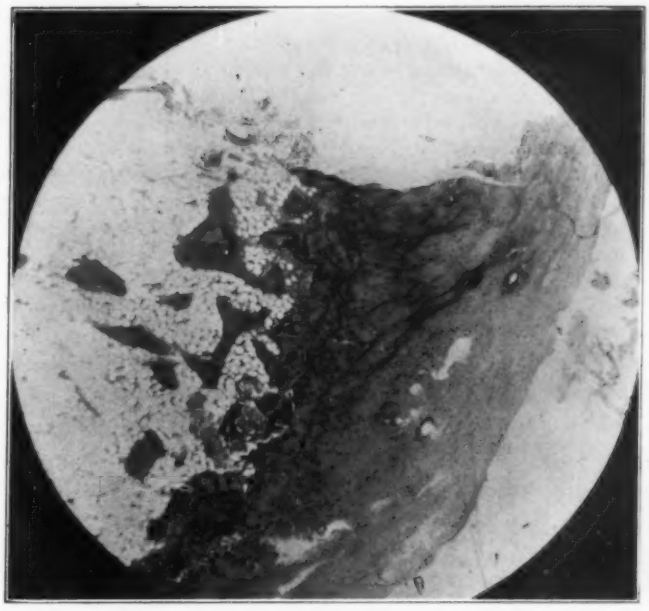


FIG. 3

CASE 1. A. C. Photomicrograph of osteoma.

Herewith are presented three cases of osteomata occurring at the lower end of the tibia, causing a distinct thinning of the shaft of the fibula by mechanical pressure:

CASE 1. A. C., aged six, was a patient at the Children's Hospital School. The family history and past history were essentially negative. Three years ago a lump was noticed at the lower end of the left leg, then about one-fourth its present size. There was no history of injury or pain, but the lump gradually increased in size, the growth being more marked during the last year.

Physical examination was negative except for the special condition. Examination showed a prominence the size of an egg, two fingers' breadth above the external malleolus. This prominence was not tender but firm, uneven and definitely circumscribed. The roentgenogram (Fig. 1) showed a tumor arising from the cortex and extending well into the soft tissue.

Operation was performed at the Children's Hospital School by Dr. Johnson on September 5, 1923. A tumor the size of a small egg, arising by a broad base and completely covered with cartilage, was easily shelled out from the tibia. Recovery was uneventful and the roentgenogram nine months after operation showed the growth completely removed. The fibula was regenerated and showed much new cortical bone and no medullary canal (Fig. 2).

CASE 2. L. S., four years old, was seen at Dr. Baer's office December, 1921. Past history and family history were negative. There was a swelling of the right foot of one year's duration with no pain and no history of injury. Examination revealed swelling about the external malleolus extending backward, forward, and slightly inward from the tibia. This swelling was hard and lumpy. The roentgenogram showed the typical mushroom appearance of osteoma, mechanically interfering with the ankle joint and by pressure causing changes in the astragalus. Operation was advised but refused.

CASE 3. J. L. H., a boy of eleven years, entered the Children's Hospital School in

October, 1921. The family history and patient's past history were negative except for the usual diseases of childhood. Eight years ago there was an injury to the left ankle and afterwards a lump was noticed above the ankle. During the last three years the leg has bowed. One month ago the boy had another fall and since then has not been able to use his left foot. The physical examination was negative except for special condition. The examination showed a bowing of the lower third of the left tibia, swelling of the lower end of the fibula and of the ankle joint with very little motion in the ankle and sub-astragloid joint. The roentgenogram showed osteoma of the external surface of the lower third of the left tibia, encroaching on the fibula and causing pressure atrophy. There was also a bowing of the tibia and a fracture of the astragalus.

Operation was performed in October, 1921, and the tumor removed, the fibula being fractured in removal. The postoperative course was uneventful. Roentgenograms taken twenty-four days after the operation showed a cavity in the tibia and a fracture of the fibula with callus formation, and a fracture of the neck of the astragalus with downward displacement of the proximal fragment.

AN UNUSUAL CASE OF LEGG-PERTHES' DISEASE

BY FREDERICK C. KIDNER, M.D., DETROIT, MICHIGAN

L. L., a boy of eight years born in the United States, appeared at the Children's Hospital in Detroit in June, 1925, with the following story: The first time his mother bathed him she noticed that his left leg seemed weaker than the right. He was rather late in walking and the weakness in the left leg persisted. Gradually a limp developed which lately has become noticeable. In recent years there has been slight pain in the left hip. Two years ago the child burned the front of his left thigh without being conscious of it. This burn took six months to heal. It was then discovered that there was no sensation in the anterior part of the left thigh. The mother has taken the boy to various clinics without having obtained satisfactory diagnosis. Various courses of treatment have been prescribed but have never been carried out.

The child was carefully studied in the Children's Hospital with the following results: The blood Wassermann was negative, the results of the blood and urine tests were normal. The general physical examination was entirely normal with the exception of the lower spine, the left hip, and left thigh, and moderately enlarged tonsils.

X-rays showed nothing abnormal except occult spina bifida of the fifth lumbar vertebra. Neurological examination by various members of the hospital staff finally led to a tentative diagnosis of "radiculitis" of the first, second, third, and fourth left lumbar nerves, possibly dependent on a spina bifida. Physical examination of the hip and leg at this time showed the following measurements: right leg 25¼ inches, left leg 24¾ inches, right thigh 15 inches, left thigh 13¼ inches, right calf 9¾ inches, left calf 8¾ inches. Motion of the hip was limited only about fifteen degrees in all directions. There was no spasm or pain on motions. The head of the femur was much more prominent than usual but was in the usual position. Knee motions were normal and all muscles of the leg were active. Left knee jerks were much reduced. The plantar was normal. The patient walked with a moderate equinus. The whole anterior two-thirds of the thigh and lower leg were completely anaesthetic; the posterior one-third was, on the other hand, hyperaesthetic. The x-ray of the hip at this time showed great shortening of the neck of the femur with considerable increase in thickness. The appearance was as though the head had been completely destroyed and left a rough superior surface to the neck. The head was represented only by three very faint shadows which might represent a disintegrated ossification centre. The acetabulum was wider and flatter than normal and there was some loss of calcium in the left side of the pelvis.

The only tenable diagnosis at this time seemed to be Legg-Perthes' or coxa plana.

The diagnosis was so important to the future of the child that the mother, who is an intelligent woman, readily agreed to an exploration for the purpose of making a diagnosis. Operation was therefore done on August 28, 1925. Through an anterior incision the head and neck of the femur were exposed. The neck was much shortened and the head extremely flattened. On opening the capsule, the joint was found to be perfectly smooth and the cartilage normal in appearance, except that it was slightly yellower than normal. Two specimens were taken: one was cut at right angles to the axis of the head so that the whole thickness of the head was involved. Only at the very deepest portion of this specimen was any bone encountered. The other was taken through the junction of the head and the neck of the femur, showing the tissue at the epiphyseal line. The wound closed in the ordinary manner and a plaster-of-Paris was applied. The boy made an uneventful recovery and has now gone home still wearing a light plaster, for protection. Motion in the hip is practically normal.

Knowing Dr. D. B. Phemister's interest in the possible infectious origin of Legg-Perthes' disease, I sent the specimen to him in Chicago where he very carefully prepared and examined it. His report was as follows:

> The large specimen, consisting of a wedge cut out of the epiphyseal cartilage and center of ossification of the head of the femur, was cut in two before decalcification. The other slide is from the small piece of bone from the neck of the femur. This section (Section 1) from the piece of bone from the neck is triangular in shape and has a small island, apparently of the epiphyseal disc, at one end. It is composed of cancellous bone with new bone along one side, which appears to be the cortex. A part of the other side

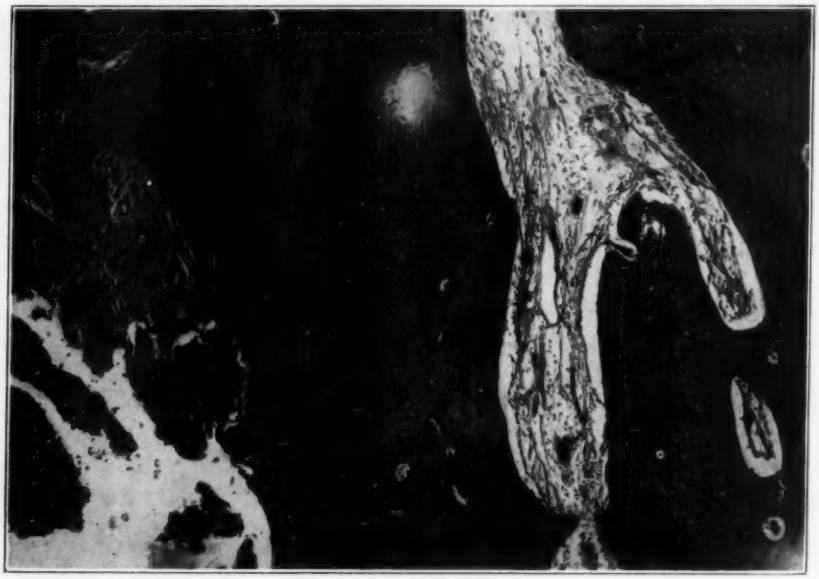


FIG. 1

Photomicrograph showing a portion of Section 1. (X75)

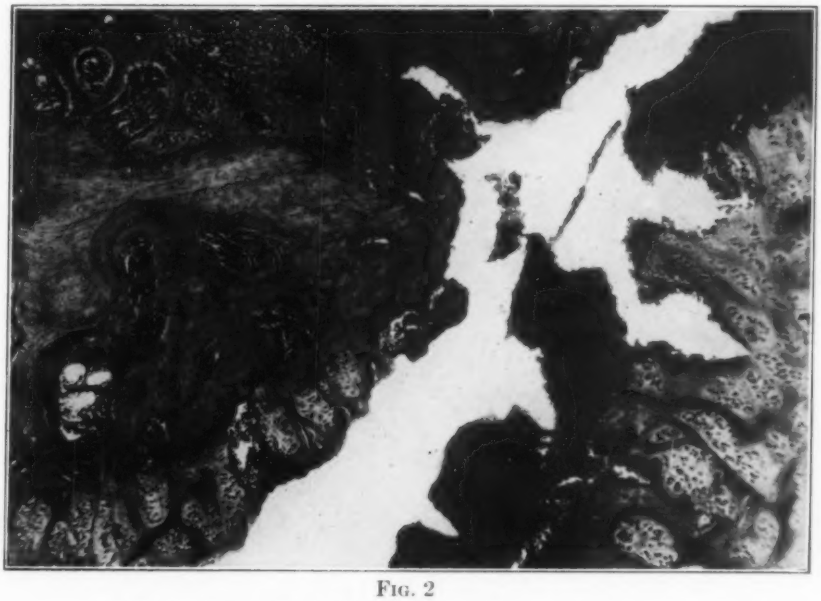


FIG. 2

Photomicrograph showing a portion of Section 2. (X75)

has apparently bordered on a cavity, as it shows an incomplete layer of fibrous tissue and old blood with osteoclasts, which are absorbing the bone. There are also islands of new bone along this surface. The short side of the triangle is the cut surface. The cancellous spaces of the bone are filled mainly with fibrous marrow, there being few hemopoietic cells. The section at the right end of the slide shows these changes best. These changes are mainly reparative, although some of them are absorptive, and there is no sign of inflammation in the newly formed unossified elements (Fig. 1).

The second section consisting of cartilage of the epiphysis with a narrow margin of the center of ossification, shows changes in both cartilage and bone. There is an irregular zone of separation at the junction of bone and cartilage, which runs mainly through cartilage, and the space is filled with old organizing blood clot. The cartilage shows some areas of degeneration and others of cartilage proliferation, with the formation of islands of fibrocartilage. The bony portion shows marked evidences of bone absorption and new bone formation, and the thick, dense area at the middle of the section is apparently old dead bone, as its lacunae are empty. There is new bone about its periphery, which apparently is being formed as the old bone is absorbed and replaced by creeping substitution. I see no evidence of inflammation. The changes appear to be those of necrosis affecting both bone and cartilage, with absorption of cartilage and bone and replacement of the dead bone by new bone (Fig. 2).

The third section, consisting of a thick layer of cartilage, shows little change in the peripheral portion along the articular surface, but extensive degeneration and absorption with partial replacement by connective tissue and fibrocartilage in its deeper portions where it was joined to bone. There is only a small island of newly formed bone in the deeper portion of the section (Fig. 3). These changes are somewhat like those seen in articular cartilage in arthritis deformans.

The changes in the epiphysis in this case are both degenerative and reparative, the degeneration affecting the deeper portions of the cartilage and apparently most of the bone. Absorption has taken place in both the damaged cartilage and bone and there is marked degeneration and replacement, particularly of bone, without existing

FIG. 3
Photomicrograph showing a portion of Section 3. (X75)

FIG. 4
Roentgenogram taken two months after operation.

evidence of inflammation. The findings favor the view that the condition is the result of circulatory disturbance and they speak against inflammation. Of course, the process is of long standing and the inflammatory signs may have long since disappeared. My opinion is that, despite the early age of onset, the condition should be regarded as Legg-Perthes' disease.

The roentgenogram shown was taken in October, 1925, two months after operation.

This, then, would appear to be a case of an unusual non-infectious interference with bone and cartilage growth in the upper end of the femur. The changes are more extensive than usually seen in Legg-Perthes' disease or coxa plana.

COMPENSATION *VS.* CORRECTION IN THE TREATMENT OF STRUCTURAL SCOLIOSIS*

BY A. STEINDLER, M.D., F.A.C.S., IOWA CITY, IA.

The last three decades have witnessed the birth and development of a good many methods for the treatment of structural scoliosis. The best in thought and application the profession had to offer has been centered in the endeavor to struggle successfully with a problem at once so important and so perplexing. Certainly, it was not for lack of interest and endeavor that the hopes, revived with every new procedure, have never been fully realized. Says Roederer, a connoisseur on the subject: "The treatment of structural scoliosis is a perpetual lesson in humility".

However one may feel about the merits of current methods, the situation does not seem such as to be quietly accepted, nor does the problem seem to be solved even in principle, let alone in application.

The feature common to all methods of correction is the application of direct force upon the site of deformity, or rather upon the center of the deformity, be that force applied by traction, pull, or pressure. It is the principle of direct realignment of the deformed spine. The presupposition is that the scoliotic spine is amenable to correction by such applications of direct force, so that symmetry can be obtained, or at least be approached to a substantial and useful degree. It is further supposed that the realignment obtained will be sufficiently stable and under control to prove permanent. This latter point is emphasized because most methods claim maintenance of the correction upon their own merits, and the policy of permanent stabilization by external or internal (operative) splinting logically followed only when permanency of correction could not be shown.

It will help in this analysis to remember that structural scoliosis is a true contracture. When muscular control necessary for the maintenance of symmetry of the spine has become lost, the spinal column is left to its own natural inertia. Under the influence of gravity it moves into the position of deformity by a well established obligatory route which is strictly prescribed by the mechanical arrangement of the intervertebral articulations. This route leads necessarily to lateral bend and convex side rotation. Concave side rotation is a position which does not harmonize with the propensity of the spine to follow its inert tendency when under the influence of gravity. Therefore this position cannot be assumed without definite muscular effort and, because it runs counter to the force of gravity, its presence shows that there still exists some muscle control over the contracture. Consequently it is never found in definite structural scoliosis.

Having considered structural scoliosis as a true contracture of the

*Read before the meeting of the American Orthopaedic Association, Atlanta, April 28, 1926.

complex and multi-articular type, it now remains to establish whether such contracture may or may not be reduced to the state of normal symmetry by correction, in the same sense as we speak of correction of a clubfoot or of other contractures subject to the force of gravity. Apparently it cannot be so reduced according to the general consensus of opinion, headed by the report of the Scoliosis Committee and accepted by those who have had experience in this field. On the other hand, the price paid for whatever incomplete and insufficient restoration of muscle balance has been achieved, is invariably a relaxation of the curve, a factor which greatly aggravates the problem of maintenance of correction and which should be regarded as a severe demerit against the method. Every one has seen and treated cases which demonstrate the evil effect of relaxation of the spine obtained without restoration of muscle control.

In this study, a different point of view is advanced, namely, that under the conditions it is more to the point to leave the original curve intact and to make use of the mobile portions of the spine above and below the contracture to obtain realignment; in other words, to develop, primarily and systematically, compensatory counter curves. This is approach to symmetry by compensation.

Here the presupposition is: that the structurally scoliotic spine cannot be reduced to complete symmetry because of its rigidity; that its rigidity is an asset for stability; that this asset should not be sacrificed for the sake of incomplete and non-permanent correction. The rigidity of the spine is respected as it is in the gibbus of the tuberculous spondylitis; and as we realign the tuberculous gibbus by antero-posterior counter curves, so we may also realign the scoliotic spine by the establishment of counter curves representing deformities in opposite directions; i.e., holding the primary curve inviolate, we then equalize by compensation.

In this there may lie a contrast to current methods, but it is much more apparent than real. Thanks to the fact that the contracture resists the forcible attempts of correction, the force applied is spent in reshaping the movable adjacent sections rather than the rigid primary curve; and there is, indeed, no difference whether the rigid is moved against the movable, or the movable against the rigid portion of the spine. But in realignment of the spine by compensation the developing of compensatory curves is now the primary object of the procedure; and the mechanical and dynamic requirements of the situation must be met by appropriate technique.

NATURAL COMPENSATION

Compensation by recurving of movable sections of the spine in the manner indicated is a prime factor in the natural recovery. The observer will note the early attempts of nature to develop compensatory curves. It is the reaction of the spine at large to the scoliotic contracture. The postural, non-contracted curve has a chance to revert to complete natural symmetry. In the structural curve, however, nature has no other remedy

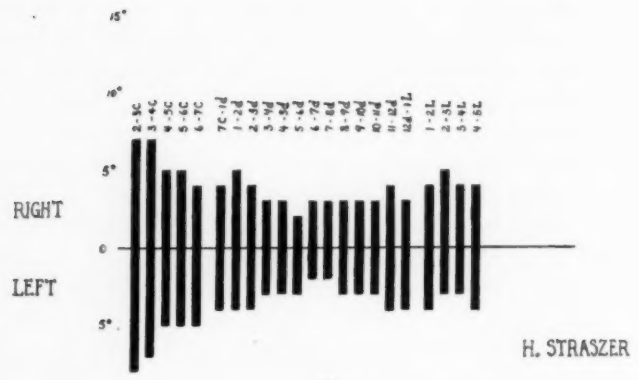


FIG. 1

Lateral Mobility of Spine. Note values for lower dorsal and upper lumbar region.

than compensation. Some curves are so held in bounds at early stages. They acquire a more or less equal distribution of body weight; compensation relieves them of preponderance of gravital stresses on the side of the curve; they become rebalanced; they may control their state of equilibrium by their own muscular effort.

NATURAL DECOMPENSATION

But most of the curves in their natural course of development do not remain compensated. At one time or another the body begins to tilt to the side of the convexity. We may call this a break in compensation. The point of the break, or the fulcrum of the tilting motion in the spine, is by no means incidental. It occurs where gravital stress is great and motion is most free. Figure 1 shows a graph of lateral motion; Figure 2 that of rotatory motion of the spine. Aside from the cervical, it is most extensive in the lower dorsal spine. In regard to vertical mobility or extensibility, we have found that the extensibility of the spine to traction is especially noticeable in the lumbo-dorsal junction. Figure 3 shows the comparison of the degree of extensibility of the scoliotic spine with that of the normal; the charts show that the ratio varies from 5 to 1, to 2½ to 1 in favor of scoliotic spines which are either naturally relaxed or have been relaxed by extensive treatment. This explains the frequency of decompensation of the spine at the dorso-lumbar level and the ease with which it occurs (Fig. 4).

Next we must consider the disalignment of the body half *below* the level of decompensation. It is obviously not possible for the body to tilt

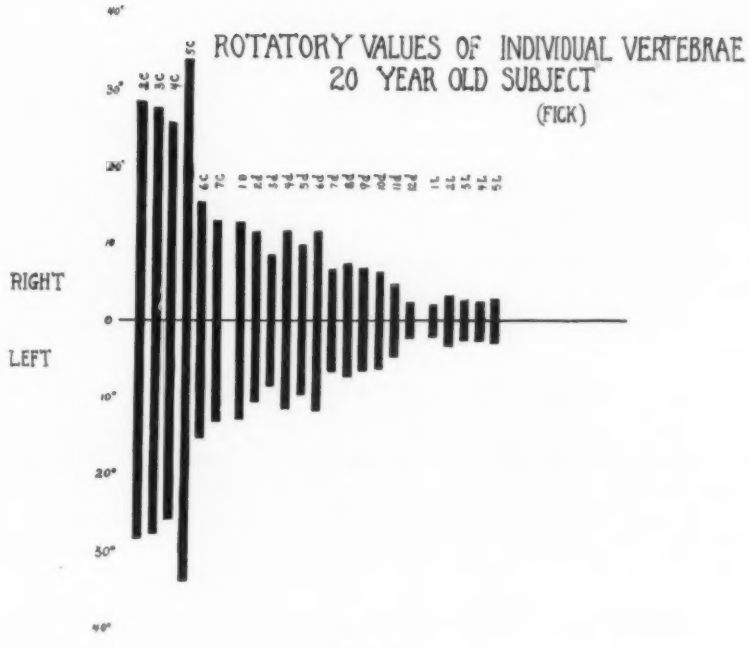


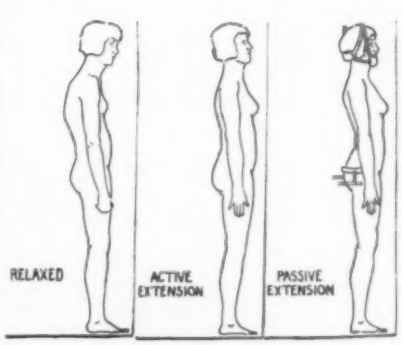
FIG. 2

Rotatory Mobility of Spine. Note restriction of rotation lower dorsal and lumbar spine.

EXTENSIBILITY OF SCOLIOTIC SPINE

RATIO TO STANDING HEIGHT AND LENGTH OF SPINE

TYPE	AVERAGE STANDING HEIGHT, CM.	AVERAGE EXTENSIBILITY	% OF STANDING HEIGHT	RATIO TO NORMAL EXT. ++ % OF LENGTH OF SPINE	FIGURES
PARALYTIC	138	4.25	3.2%	9.4:182	
HABITUAL	155	2.97	1.6%	4.8:182	
RHACHITIC	139	3.9	2.8%	6.9:182	
CONGENITAL	135	2.4	1.8%	5.9:182	



+ PASSIVE EXTENSIBILITY. TRACTION = ⅓ BODY WEIGHT
++ STANDING HEIGHT TO OCCIPITO – SACRAL DISTANCE = 3:1

FIG. 3

Extensibility of Spine. Normal and Scoliotic. Note increase of extensibility in Scoliotics.

SITE OF DECOMPENSATION (PRINCIPAL)

TYPE	LUMBO-DORSAL	SACRAL	CERVICO-DORSAL	TOTAL	
PARALYTIC	42 71%	17 29%		59	
HABITUAL	30 80%	8 20%		38	
RHACHITIC	12 86%	2 14%		14	
CONGENITAL	15 80%	3 17%		18	
EMPYEMATIC	6 86%		1 14%	7	
TOTAL	105 77%	30 22.3%	0.6%	136	

FIG. 4

Site of Decompensation.

to one side above the fulcrum without a corresponding translatory motion of the pelvis below in the opposite direction. Since the line of gravity must fall within the weight-supporting surface of the feet the latter may be considered as the fixed point of the system. Consequently, with this

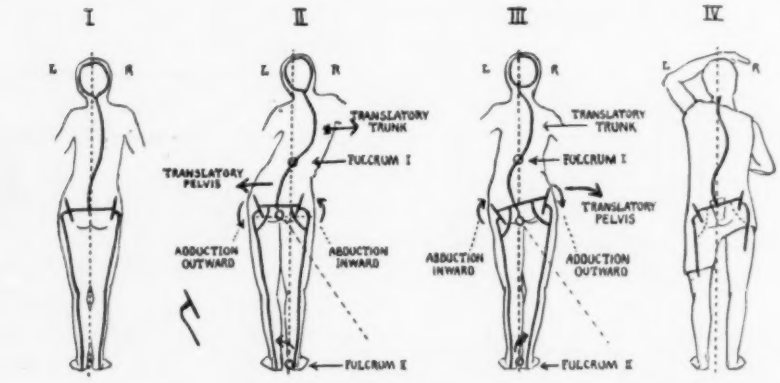


FIG. 5

Relation of Pelvis to Trunk.

II. Decompensation: Shift of pelvis to concave side: concave hip in adduction and outward rotation, convex hip in abduction and inward rotation; perpendicular from heels up to right of gluteal fold.

III. Compensation: Shift of pelvis to convex side: concave hip in abduction and inward rotation, convex hip in adduction and outward rotation; perpendicular from heels in gluteal fold (mid-pelvis).

FIG. 6a

FIG. 6b

FIG. 6c

FIG. 6d

Side Shifting.

a. Relaxed, feet together.
b. Shifted. Note surplus body weight to left.
c. Relaxed, feet apart.
d. Shifted. Note surplus body weight to left as in b.

shift of the pelvis due to decompensation, the hip on the concave side goes into adduction and that on the convex side into abduction; also, as the primary curve becomes longer the compensatory lumbar curve which nature has tried to establish is flattened out; lastly, as the pelvis rotates in the sense of the primary curve, the hip on the side of the convexity goes into inward rotation, and that on the side of the concavity into outward rotation (Fig. 5). The diagram, therefore, presents all the cardinal features of derangement from normal position which the pelvis undergoes with the advent of decompensation. So definite is this sign of decompensation impressed upon the normal course of structural scoliosis that it often stands out as the first symptom of body disalignment, and it marks a decided progress of the deformity. All this goes to show how intimately the pelvis is involved in the disalignment and how erroneous it is to consider it as a fixed point. It cannot be used as a stable basis upon which the structure of mechanical redressment is to be erected. The principal point of our technique is, in fact, the inclusion of the pelvis in the arrangement of compensation.

COMPENSATION

Now, if this natural break in compensation, with its effect on the position of the pelvis and hips, so thoroughly influences the entire body mechanics, what effect would it have upon the proper redistribution of

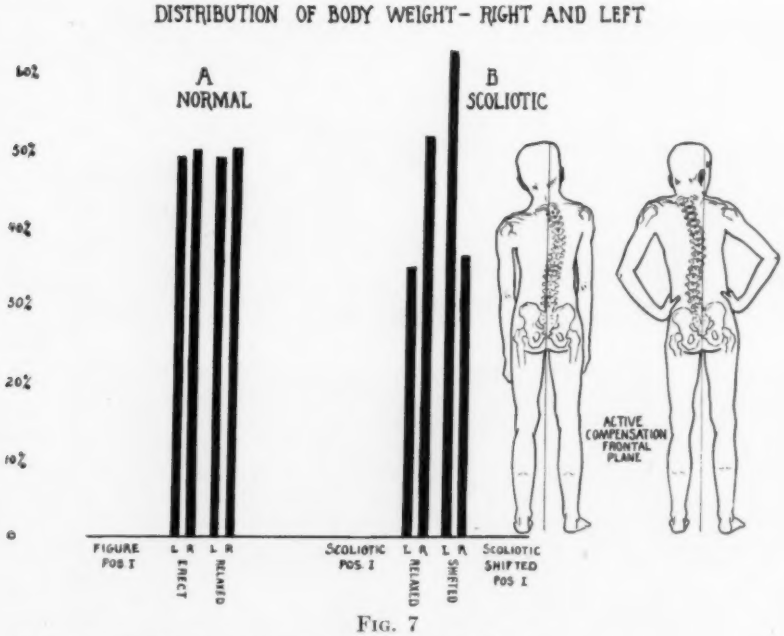


FIG. 7

Distribution of body weight by shifting frontal plane.

B. Relaxed: Surplus of body weight on scoliotic side.
Shifted: Surplus of body weight on concave side.
The center of gravity moves from convex to concave side.

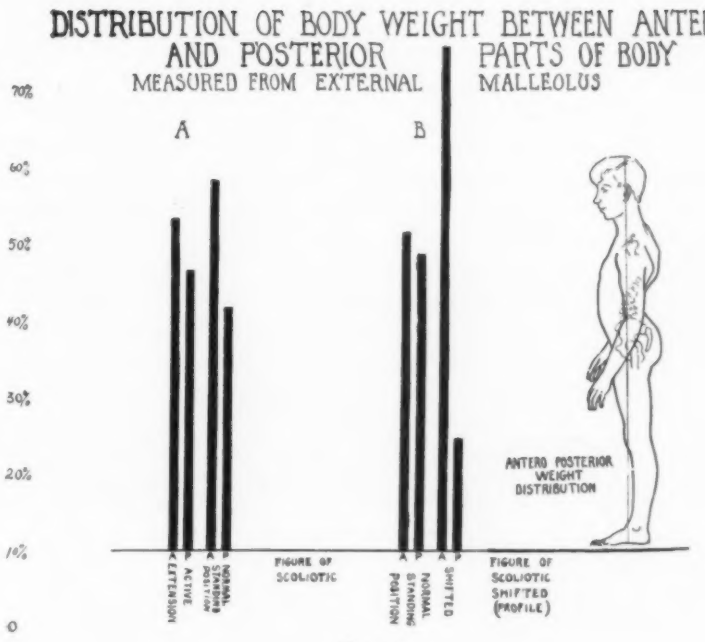


FIG. 8

Distribution of body weight by shifting. Sagittal plane.

Relaxed: equal distribution anteroposteriorly.
Shifted: very marked surplus of body weight anteriorly.
The center of gravity in shifting moves from behind forward.

body weight, should we succeed in shifting the body back to the position of compensation? In other words, when we shift the body back, shoulders over pelvis and pelvis over ankles, what becomes of the center of gravity? If the mobility of the body over the fulcrum is maintained, such shift is possible and it is a distinct point in the treatment to enable and to teach the patient to shift. Figure 6a shows the distribution of body weight in the scoliotic as he stands, feet together, with the preponderance of weight on the scoliotic side. Figure 6b shows the change in distribution over the two halves of the body when he shifts, with the preponderance on the concave side. Figure 6c shows the distribution of the body weight as he stands with legs apart; the difference is less but there is still a preponderance on the scoliotic side. Figure 6d shows him as he shifts; the weight distribution is equal to that upon shifting with his feet together.

Figure 7 shows graphically the redistribution of body weight on side shifting in the frontal plane. Figure 8 shows the weight shift in the antero-posterior direction. Notice that the predominance of body weight now moves from the convex side posteriorly to the concave side anteriorly. The center of gravity has been displaced in diagonal direction from backward and right to forward and left.

TREATMENT

The application of this analysis to the treatment by compensation results in the following features: The lumbar compensatory curve must be produced or accentuated:

First, by a shift of the body to the concave side with the attending displacement of the gravital stress in the described manner.

Second, by inclusion of the pelvis in the arrangement of compensation. This inclusion must place the pelvis in the position opposite to that which it had maintained while the body was in decompensation. This means that the hip on the concave side must be held in abduction.

Third, the pelvis must also be rotated, corresponding to and on the side of the lumbar compensatory curve (Fig. 9). We shall have obtained

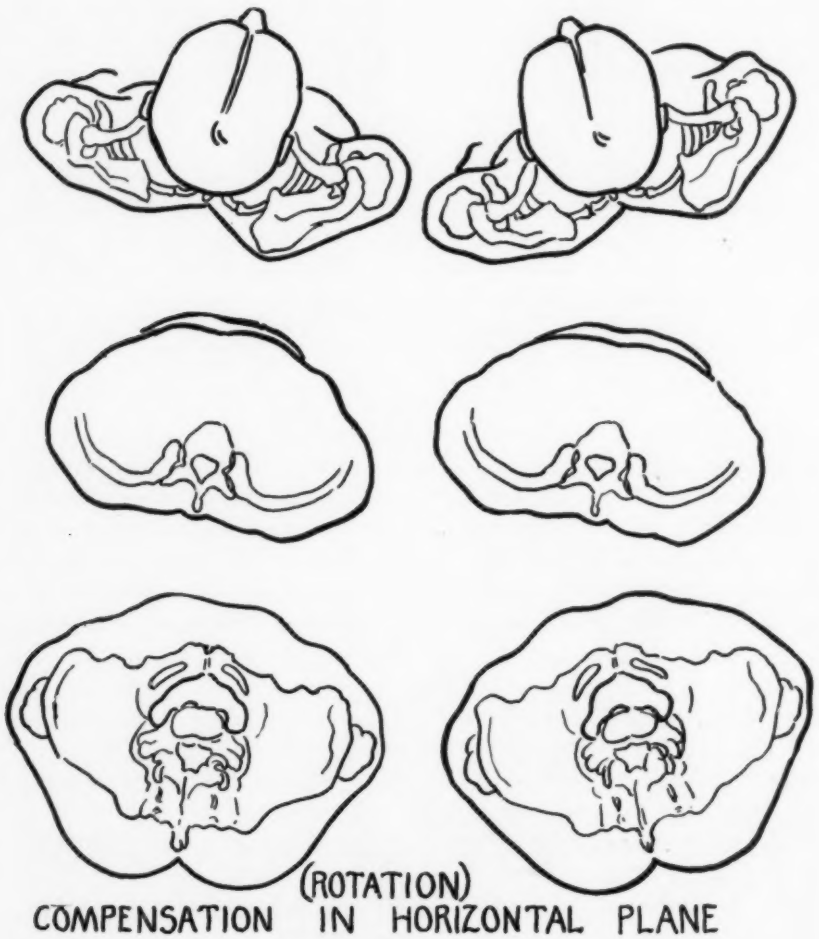


FIG. 9

Compensation in horizontal plane. Counter-rotation of upper dorsal and lumbar spine.

FIG. 10a

FIG. 10b

FIG. 10c

FIG. 10d

Mobilization Period

a. Pelvic mobilization.
b. Oblique seat.
c. Shifting.
d. Creeping.

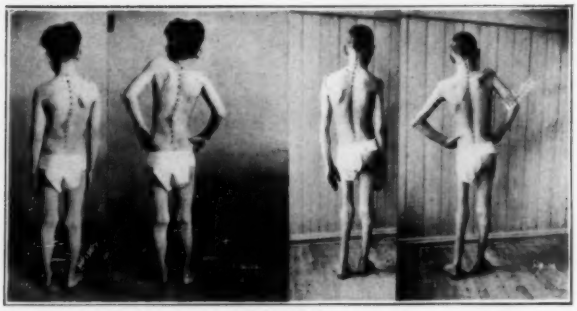


FIG. 11
Active Shifting.

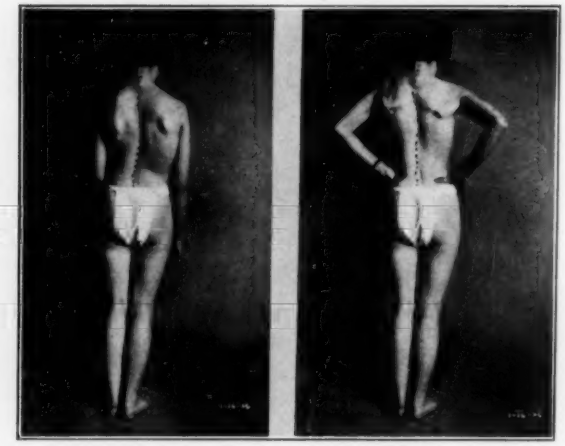


FIG. 12
Active Shifting.

then both lateral and rotatory compensation below the scoliotic contracture and with it the proper redistribution of body weight. A similar arrangement of compensation is often (not always) necessary for the portion of the spine above the primary curve.

1. *The Period of Scoliosis Gymnastics.* The spine is first mobilized in its lower and upper portions by adequate exercises and manipulations, by bending and swinging exercises of legs and pelvis in prone position, by the oblique Zander seat, by active side bending and rotatory exercises, by active arm and shoulder girdle drill, and finally by Klapp's creeping exercises (Fig. 10).

The patient is then taught the active shifting until he is able to carry the body well over the pelvis and beyond, toward the side of concavity (Fig. 11 and Fig. 12.) These exercises are continued until active compensation has reached the highest possible degree. From two to six weeks of strenuous training are necessary for this work.

2. *Fixation.* This corrected position is then definitely established in a plaster-of-Paris cast. The most important point in its application is that the pelvis is included by placing the hip on the concave side in abduction and extending the cast over this abducted thigh. The idea of including the contralateral hip has been utilized before by Hohmann, Schultess and others; and the writer in 1909 described a scoliosis brace based very much upon the same principle.

While the cast is being applied the patient stands upright with the contralateral hip slightly abducted, the head is stabilized by slight traction and the arm on the concave side is elevated. He is then told to shift, and, by this movement, he carries the trunk strongly toward the concave side, thereby markedly accentuating the compensatory lumbar curve.

In order to compensate for rotation as well as lateral deviation the primary dorsal curve is first held immobile, either by the hands of an assistant or by a system of straps. The shoulders are then rotated backward on the left (concave) side in conformity with the upper (left) compensatory curve which has been produced by the elevation of the arm. Another assistant rotates the pelvis backwards, also on the concave (left) side, so that this rotation likewise corresponds with the compensatory lumbar curve on the left. The body is now compensated both in the frontal and sagittal planes by the establishment of the upper and lower compensatory curves and their attending rotation. The period of fixation in plaster-of-Paris casts usually extends over three to five months and during this time the casts are changed on an average of every three or four weeks. If the patient is a candidate for operative fixation because of the instability of the spine and of inherent muscle loss, the routine preparations are then made for operative fusion. A cast is applied just before the operation in the position of compensation, and is bivalved and used as a double plaster shell during the eight weeks' period of recumbency following operation. If, on the other hand, the

COMPENSATION BY TREATMENT
(61 CASES)

TYPE	COMPLETE	INCOMPLETE	TOTAL	
PARALYTIC	77%	23%	47	
HABITUAL	77%	23%	17	
RHACHITIC	88%	12%	9	
CONGENITAL	73%	27%	11	
TOTAL	48	13	61	

FIG. 13a

MAINTENANCE OF COMPENSATION BY FUSION
(48 CASES)

TYPE	COMPENSATED	NOT COMPENSATED	BREAKS	TOTAL	
PARALYTIC	11 61%	5 28%	2 11%	18	
HABITUAL	13 81%	2 13%	1 6%	16	
RHACHITIC	3 75%	1 25%		4	
CONGENITAL	7 78%	2 22%		10	
TOTAL	34	10	4	48	

FIG. 13b

a. Compensation by Treatment.
b. Maintenance of Compensation by Fusion.

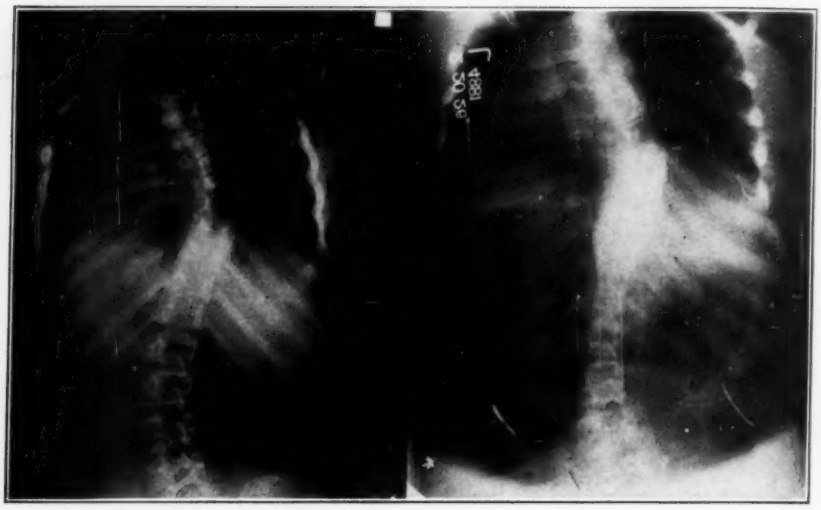


FIG. 14a

FIG. 14b

FIG. 14c

FIG. 14d

B. M., 14 years, Compensation cast, (under treatment).

a. Feb. 20, 1926.
b. July 7, 1925.
c. Feb. 22, 1926.
d. Feb. 22, 1926.

patient is considered sufficiently compensated, his spine stable enough, and his muscles sufficiently developed to warrant the hope of his actively maintaining the required equilibrium, he is then returned to the gymnasium for intensive muscle training and is later sent home with instructions to continue these exercises for a period of years.

THE MAINTENANCE OF COMPENSATION

Probably the most important problem is that of maintaining the body in compensated position. This maintenance of the realignment of the spine is now being more and more relegated to the operative procedure of stabilization, since experience has taught that a greater portion of the spines cannot be held by corrective methods alone.

The writer also has been compelled to resort to such operative methods in the majority of cases. Nevertheless there is good reason to believe that compensation, if complete enough, will enable a number of spines to main-

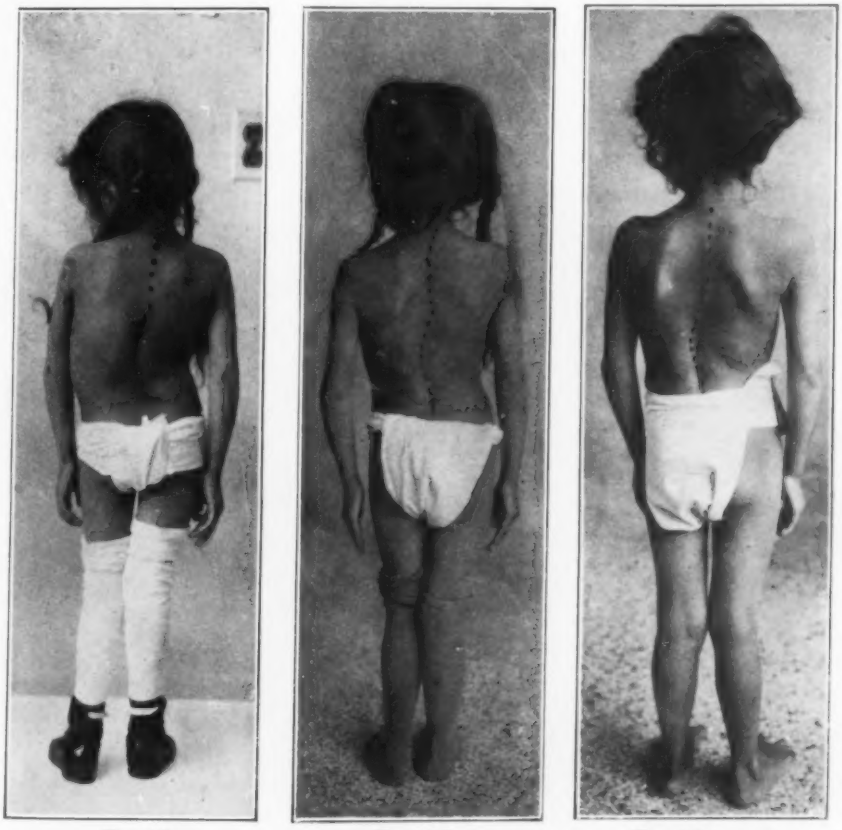


FIG. 15a FIG. 15b FIG. 15c

J. A., 8 years, Preoperative compensation followed by fusion.

a. Jan. 8, 1924.
b. May 12, 1925.
c. Nov. 3, 1925.

FIG. 16a

FIG. 16b

FIG. 16c

FIG. 16d

FIG. 16e

FIG. 16f

FIG. 16g

E. D., Preoperative compensation followed by fusion.

a. May 15, 1923. b. May 15, 1923. c. Sept. 16, 1924. d. Sept. 16, 1924.
e. Apr. 11, 1925. f. Apr. 11, 1925. g. Mar. 2, 1926.

tain their balance indefinitely upon their own muscle power and that they, consequently, may escape the necessity of operation. As for the paralytic group, probably all of these will have to be stabilized, and, possibly, most of the cases of the congenital type. But in the habitual and rachitic groups, many of the cases may escape the necessity of operation by early and thorough compensation and systematic development of muscle control.

Furthermore, a marked degree of decompensation is a menace to the stability of the spine even if operated upon.

Figure 13a shows the effect of treatment upon compensation in general (61 cases: complete 48, incomplete 13), Figure 13b gives the statistics on compensation treatment followed by fusion (48 cases: 34 complete, 10 incompletely fused; 4 breaks by pseudoarthrosis).

In all reoperated cases we found fusion complete, except for the one point of pseudoarthrosis. We therefore believe that the occurrence of motion within the fused area is not so much due to errors in technique, but to the great tension stress upon this point in these non-compensated spines, especially since all breaks occurred in the lumbo-dorsal junction.

SUMMARY

It is submitted for consideration:

That the current methods of direct application of force to the scoliotic

FIG. 17a

FIG. 17b

FIG. 17c

N. J., 12 years, Paralytic. Compensation and fusion.

a. Feb. 28, 1925.
b. Oct. 1, 1925.
c. Oct. 5, 1925.

contracture do not produce the desired degree of correction, and that they, by virtue of the resulting relaxation, aggravate the problem of maintenance of correction.

That, on the other hand, the realignment of the spine by compensation attains a satisfactory degree of body symmetry and of proper redistribution of weight without relaxation of the spine; that this method, therefore, does not interfere with maintenance of position, but enhances it by alleviating gravital stresses.

That, furthermore, a number of cases realigned by compensation may be expected to hold their equilibrium indefinitely by their own muscle power.

Finally, that those spines in which subsequent stabilization by operative means will be necessary, are, by virtue of this realignment by compensation without relaxation, in better position to hold after operation than those operated upon in state of decompensation.

DISCUSSION

Dr. Samuel Kleinberg, New York, N. Y.: I will limit myself to a consideration of three important points that have been presented by Dr. Steindler. First, the principles governing the correction of a curvature of the spine; second, the best means of obtaining correction; and third, the most effective procedure for maintaining improvement and checking increase in deformity.

There are many theories regarding the principles governing the correction of scoliosis which might be adduced for discussion, but it appears to me more profitable to review only those which have practical value.

The first factor is the force of gravity. We do not know what the exact forces are which are ultimately responsible for a curvature of the spine, but we do know that the force of gravity has a very important influence both in maintaining a curvature and in aggravating it. It is common knowledge that a paralytic curvature is greater when the patient is sitting or standing than it is when he is recumbent, and this holds true also, although it is less evident, in the vast majority of the so called idiopathic cases of scoliosis. The first principle, therefore, involved in the correction of scoliosis is the elimination or reduction of the influence of the force of gravity. This is usually accomplished by some form of apparatus, or better still by treatment of the patient in recumbency.

The second point relates to the pathology. I agree entirely with Dr. Steindler that scoliosis may be considered a contracture deformity. Hence our problem is to stretch the contracted tissues. This is best done by reversing the patient's posture. The value of this change lies in the fact that when the attitude of the trunk is reversed the function of the vertebrae, the intervertebral ligaments and the muscles will become altered and adapted to a new position, and as a result of the changed function there will be a change in the structure and conformation of the spine and trunk.

The third principle governing the treatment of scoliosis depends on the fact that the tissues of the trunk are elastic and that the spine is actually a flexible, curved rod. I concur entirely with Dr. Steindler in his opinion that the shoulder and pelvic girdles enter into the formation of the curvature nearly as much as the spine and the thoracic skeleton, and that no treatment is complete or competent that does not include proper control of these parts. However, whether we fix the two extremities of the scoliotic spine, by immobilizing the shoulder and pelvic girdles, and exert corrective force on the so-called fixed segment, or hold the fixed segment and attempt to obtain compensatory correction by changing the curves of the spine above and below it, is, I think, a

subject for theoretical argument rather than one of any great practical import. Both methods are effective. The result of the corrective measures depends on the type and degree of curvature rather than upon the exact details of the technique. In general we must combine judiciously longitudinal and lateral traction and a derotating force applied either to the fixed spinal segments or to the shoulder and pelvic girdles, depending upon which procedure is the more effective in a given case. The exact methods used to carry out these principles is more a matter of personal taste and experience, but they constitute the dominant factors upon which depends the effectiveness of any form of treatment.

The next point which I wish to stress is the most effective means of obtaining the maximum correction. Formerly, most if not all of the methods of forcible correction depended upon immobilization of the shoulders and pelvis, that is, the extremities of the spine, and the application of lateral or anteroposterior force to the ribs over either the convex side of the back, or the convex side of the front of the chest. This method applied with the patient in vertical suspension gives very satisfactory results. I wish to here speak of a different treatment: one that is fairly rapid, very much more comfortable, more effective and free from the many apparent disadvantages of any form of forcible correction by plaster-of-Paris jackets. For the last five or six years we have been using at the Hospital for Ruptured and Crippled the following procedure. The patient is placed on a convex frame, having an angulation of about 140 to 160 degrees. On this he lies continuously. Several days are allowed for the patient to become accustomed to the new position. Traction by means of weights is then applied to the head and to the pelvis. The weights are increased every few days until the maximum correction is obtained. A total pull of fifty pounds is a fair average and is borne well even by a child of twelve years of age. Sometimes lateral traction is used. During this treatment the patient is able to read, write, or sew, has no pain in the chest or trunk, and is in general quite comfortable. The primary effect of this treatment is that the appearance of the back is improved. The curvature rapidly becomes reduced, the projection of the convex ribs is diminished, the front of the chest loses much of its asymmetry and the width and expansion of the chest are increased. By this simple and practically painless method we can obtain the maximum potential improvement in four to eight weeks. In the moderate and severe types of scoliosis, I believe that we can obtain a greater measure of correction by this method than by forcible correction in jackets.

This treatment has the added advantage that the patient can exercise his trunk and extremities, and massage may be used to maintain the tone of the muscles. I consider this method to be the simplest, the most rapid and the most effective for the correction of a structural curve. In this system we utilize the principle of treatment propounded by Dr. Steindler, namely, obtaining correction and compensation by mobilizing and altering the secondary curves.

When the maximum correction has been obtained either through plaster jackets, or preferably through treatment on a convex frame with traction, the next problem that arises is the one so ably emphasized by Dr. Steindler, namely, the best means of maintaining the correction. We have two methods at our disposal. We can apply a supporting plaster jacket which may be kept on for a period of six months or a year until the spine has been stabilized, when a corset may be given and exercises instituted to strengthen the muscles; or an operation may be performed on the spine to thoroughly fix the major segment of the curve by osseous union of the vertebrae, in the hope that if a large section of the spine is ankylosed, it will not undergo any further deformity and hence the scoliosis will be checked.

On the first division of the Hospital for Ruptured and Crippled we have performed about one hundred and twenty-five fusion operations for all varieties of structural scoliosis. Dr. Armitage Whitman and I are now engaged in investigating the results of these operations. In the five year period ending in 1924 we performed ninety-six fusion operations. So far we have examined forty cases of this series. The operation

was performed primarily to check deformity, hence it was done only where there was a history of increasing deformity, or where it was reasonably certain that the curvature was such that it would become worse. In the forty cases there was a distinct history of increasing deformity in thirty-seven. In one case there was an advanced vertebral epiphysitis, and in the remaining two patients the clinical appearance suggested the likelihood of increasing deformity.

All of the wounds healed by primary union. The time elapsed since the operation varied from one and a half to six years. In thirty-five of the forty cases there was an increase in height varying from one to four inches. Of the remaining five patients three were already fairly tall and no increase in height was expected. In two very severe cases there was no change in the height. These figures show conclusively that the operation does not retard growth.

There was stiffness of the back in all the cases and actual bony ankylosis in about one third. Ankylosis was not obtained in any of the lumbar curves. The purpose of the operation was to maintain the correction and to check the progress of the deformity. From this point of view there were thirty-three excellent results, that is 82½ per cent. In two cases, or 5 per cent., the results were good and in 5, or 12½ per cent., the operation failed because the deformity increased subsequent to the fusion. From these observations I conclude that the fusion operation is effective in maintaining correction and in checking the progress of a scoliotic deformity.

Dr. Arthur F. Steindler, Iowa City, Iowa (closing the discussion): Dr. Kleinberg discussed fusion of the spine in the treatment of scoliosis and this was the real problem of my paper. I can understand, however, why he lays emphasis on this point. I have shown in my charts how the extensibility and instability of the spine increases enormously in the cases that have been treated by the old methods. There is, then, no other way out of it except to fuse it. I have further shown that nature exerts every possible means to establish a compensation and to rearrange the deranged gravital stresses. I have finally shown that in following nature's intents, we must deal with scoliosis by establishing compensation. If I am principally right, I cannot be practically wrong. Of course, you may loosen up a spine to your heart's content and then cover up the damage by fusing it solid. But if we expect to save any cases from the fate of operation, it must be on the basis of preserving the stability of the spine, and by rearranging the center of the gravity by means of compensatory curves until the forces of gravity no longer produce asymmetrical stresses. Then we fuse or not, without having destroyed the stability of the spine. This is the very essence of treatment by compensation.

THE TENSOR FASCIAE FEMORIS*

BY A. MACKENZIE FORBES, M.D.

Clinical Professor of Orthopaedic Surgery, McGill University, Montreal, Canada.

The function of the tensor fasciae femoris and that part of the gluteus maximus which is attached with it into the tibia through the femoral fascia is still open to question. Some authorities state that these muscular fibres are extensors of the knee joint, and others state that they flex this joint. In certain deformities following poliomyelitis these muscles definitely flex the thigh and the knee.

In Pittsburgh Dr. Silver, with his associate, Dr. Yount, have studied these muscles as a definite deforming influence in certain of the paralyses. In the triad deformity, hip flexion, knee flexion, and knock-knee, the cause probably is the unopposed action of the tensor fasciae group acting through the ilio-tibial band. For this reason Silver and Yount suggest the tenotomy of the ilio-tibial band as an effective method of correction of both hip and knee flexion. They tenotomize the ilio-tibial band near the knee. They perform this operation in preference to carrying out the usual procedure of Soutter.

The rationale of Silver and Yount's procedure has caused so deep an impression on those associated in the writer's clinic that we have reviewed our knowledge of the anatomy of the tensor fasciae group, and we have considered whether it would be possible to use these muscles as a power for good in the triad deformity already mentioned. Those who practise tendon transplantation do so in order to convert a power for evil into a power for good. If the tensor fasciae femoris, through the ilio-tibial band, causes flexion at the knee, would it not be possible, by transplanting the latter into the patella to convert it into an extensor and thus balance muscular power about the knee?

Acting under this hypothesis, it is now to be our custom in certain selected cases to separate the fibres of fascia lata which can be proven to be acting as flexors at the knee, to dissect these from the deeper muscles of the thigh, and to fashion them into a cylindrical cord which may be transplanted into the quadriceps tendon and the patella while the leg and thigh are held in extension. We have already performed this operation with success, and because of the fact that the tensor fasciae femoris can be easily lengthened, we have had no difficulty in getting a firm attachment into the patellary tendon and the patella, where, in later months, this tendon can be clearly felt acting in its new function as an extensor at the knee.

* From the Montreal Unit Shriners Hospitals for Crippled Children, April, 1926.

OPERATIONS IN THE TREATMENT OF SPASTIC PARALYSIS*

BY H. L. VON LACKUM, M.D., NEW YORK CITY, N. Y.

New interest in the treatment of spastic paralysis has been stimulated by the recent work of Royle and Hunter in sympathetic ramisectomy. Much has been done in the past, but the hopelessness of the condition cannot be denied, and anything which offers relief either to the patient or to those who must care for him should be carried out. In conjunction with these things, a program of sterilization might, at times, be rightly performed.

In spastic paralysis, as in other paralyses, no deformity or contracture should ever be allowed to develop, and it is a sad comment on the profession that it so frequently does. Although the prevention of deformity would have been better, its correction, when once established, must be done.

Who has not noticed the brightening of the mind, in many of these cases, the new interest in life and the betterment of general health which follows the correction of even so slight a deformity as that of equinus?

This paper is not a discussion of the relative merits of the different procedures. The value of peripheral nerve resection is proved, the transfer of muscle-pull has been found helpful and the usefulness of gray ramisectomy in selected cases is, in our opinion, no longer in doubt. But in all of these procedures a knowledge of anatomy is essential, and a resumé with especial reference to the surgical aspects is not amiss at this time. Most of the things which will be said here have been said before and the reader is referred to the writings of Royle and Hunter, Stoffel, Gill, Dixon, and others. The correction of deformity will be first considered.

Equinus is most frequently encountered and it is easily corrected though its correction is not accomplished without danger. These patients are undoubtedly better on their toes with straight knees, than on their heels with crooked knees and severe calcaneus. This latter condition can be quickly produced by removing too radically the pull of the calf at the knee when correcting equinus. In other words, the continuity of the tendo Achillis should never be destroyed and a plastic lengthening should not be made too long. The pull of the calf is important in preventing knee deformity and this pull cannot be certainly maintained in the face of blind surgery, that is, by subcutaneous tenotomy, whether it be complete or of the sliding type. The means of accurate work is at hand in plastic lengthening. The exposure of the tendon should be made by an incision to its outer side where there can be no later interference from the scar.

The method of lengthening, as described by Hibbs, is recommended because of its accuracy in gaining exact length and because of its absolutely

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maintaining tendon tissue continuity. The sheath of the tendon which is definite, though not synovial, should be carefully opened and sewed back after lengthening because of its aid in tendon repair.

Flexion deformity at the knee is also corrected, though not with such ease, because of the tendency to subluxation. In order to prevent this it is sometimes necessary to divide the posterior ligament of the knee joint, in which case care must be taken in drawing aside the important popliteal structures. To do this it is always necessary to tie off the azygos vessels, which are short and straight to the joint, leaving the main trunks from directly over the posterior ligament. In this way complete exposure is gained and the wound is kept dry, a condition which is very important when the amount of scar tissue must be considered. The initial incision should be kept above the bend of the knee, also because of scar. The division of the ligament must include its lateral fasciculi in order to gain complete relaxation.

FIG. 1
Illustrating skin incisions for cervical ramisectomy (1) and approach to the obturator nerve (2).

FIG. 2
Illustrating skin incisions for lumbar ramisectomy (1), approaches to hamstring (2) and calf (3) muscle nerve supply and to the hamstring tendons (4) and tendo Achillis (5).

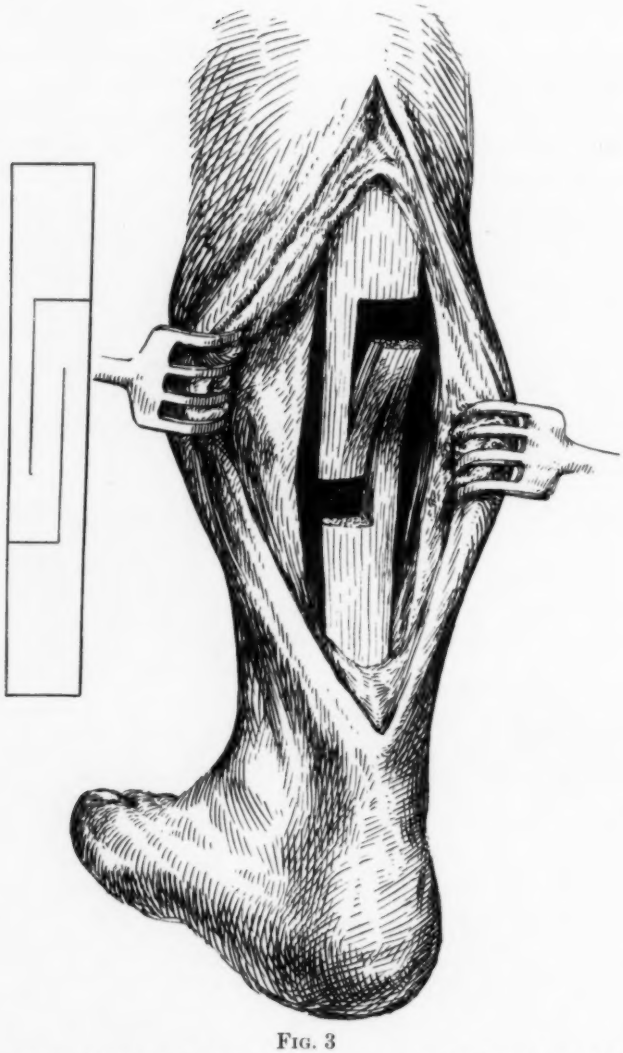

FIG. 3

Illustrating Hibbs method of tendon lengthening in which continuity is not destroyed.

The hamstring tendons are best exposed through the same or a similar single incision. They can be divided with impunity without fear of an opposite deformity, because the muscle tissue runs so low on them that reattachment is certain. In severe cases which tend so markedly to recur it is even advisable to remove a section from the aponeurotic or tendinous portions. They must be fully exposed, however, in order to escape dividing the popliteal nerves and especially the lateral or common peroneal which runs along with the biceps tendon for three or four inches of its length. The medial popliteal or tibial nerve is not in a dangerous position because it lies superficially just beneath the deep fascia and exactly in the middle of the space.

Adduction at the hip can usually be dealt with by stretching, though in the more rigid cases less damage is done to the soft tissues if the tendon of the adductor longus is divided close to its superficial origin at the body of the os pubis. Only the tendinous portion should be attacked so that there will be little, if any, bleeding. A short incision just over it suffices. When flexion has taken place, no more extensive procedure than division of the sartorius, both heads of origin of the rectus femoris and the tensor fascia femoris is necessary. This should be done close to the bone in order to have as little bleeding as possible and complete hemostasis should be had at the cost of time. It is done close to bone in preference to the sub-periosteal method because it is simpler and the results are as good. The great flesh belly of the iliopsoas will usually stretch. It should not be divided because of its importance in posture and it is not unlikely that the scar incident to division would contract and produce a more rigid deformity than the original one. After correction of the deformity, the incision which was made just back of the anterior superior iliac spine is closed by sewing the subcutaneous tissue with skin into the gap left by the separated muscles. This minimizes the amount of scar tissue and the tendency to recur.

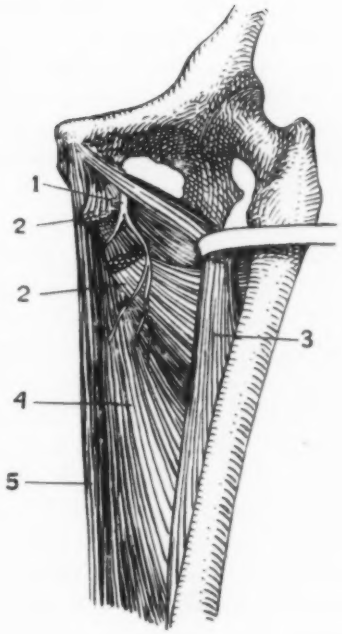

FIG. 4

Illustrating obturator nerve (1) dividing over resected adductor brevis muscle (2) with gracilis (5) and adductor magnus (4) behind and adductor longus (3) retracted laterally in front.

The objection may be raised that this correction of deformity gives only temporary relief because the factor of spasticity which produced it is still present. That is true to a degree and sometimes deformities must be corrected a second time. But complete correction once, with postoperative maintenance, is usually enough because of the exaggerated contracture of the muscle after operation and its consequent weakening.

The upper extremity can be treated similarly, and in certain cases this is cosmetically desirable, although it is doubtful whether the correction of deformity of the upper extremity is, in most of these cases, any aid to function, since the movements of the hand and forearm are so highly specialized and the actual rigidity is made no less.

Transplantation of certain muscles, such as the biceps at the knee and the flexors of the wrist, are resorted to, and, in picked cases, with good effect, especially from the standpoint of the correction and prevention of deformity. Such operations may help balance, to a degree, but they do not reduce the sum total of spasticity and lack of control; and therefore in the long run are not as effective as the other procedures, where the actual strength of the spastic muscle is reduced and the control thereby improved. In doing the biceps transplantation, it is necessary to free the muscle high so as to get as direct a pull as possible on the patella. The common peroneal nerve which lies so closely alongside the biceps must be avoided and to insure the new insertion the tendon should be implanted in the bone. In spite of good operative technique, the patella frequently becomes dislocated by the indirect pull especially when the muscle is strong enough to be really valuable as a transplant. When this has happened the knee is very seriously disabled. This possibility is the strongest argument against this type of operation and it is not advised.

The transplant at the wrist is effective cosmetically, the control not being much improved for reasons mentioned above. The flexor carpi radialis and flexor carpi ulnaris are transplanted into the extensors of the digits and in order to be effective it is essential to have the very minimal amount of scar. For that reason especial care should be used in the handling of tissues and tendon sheaths used wherever possible. The negative effect of the removal of the pull in front may be the most important factor in this transfer, but if the wrist must also be stretched to correct a contracture, post operative care in maintaining it in the corrected position must be carried out for many weeks in order to prevent a recurrence. The length of time necessary to do this varies with the degree of deformity, but each should be held until all tendency to recur has been removed.

Stoffel's procedure of peripheral nerve resection has frequently proved very satisfactory. When done, a one-inch section should be removed from the nerve attacked and when there is uncertainty as to identity of the nerve electrical stimulation should be resorted to. The impulse must be light so that the current does not spill over into nerve fibres not concerned.

The technique is difficult in the upper extremity and its usefulness limited. The reasons have already been stated.

Adductor control of the lower extremity is easily reached by exposure of the adductor or obturator nerve. An incision is made high up in the thigh just posterior to the tendon of the adductor longus. The posterior surface of this muscle must be followed closely so that the line of cleavage between it and the adductor brevis is adhered to. The anterior division of the nerve will be found running obliquely across the anterior surface of the brevis, less than an inch from the medial border of the muscles. Care must be taken to avoid dissection between the gracilis and brevis as the former lies over the line of cleavage. Also, if the incision is too low, a plexus of veins crossing the brevis will prove confusing. In severe cases the entire obturator nerve should be divided and this is done by following the anterior

division proximally to the upper border of the brevis and picking up the posterior division where it passes behind the muscle in the same sagittal plane as the anterior division. It will be remembered that all adductor power is not lost in this case because a part of the adductor magnus is innervated by the sciatic nerve and the pectineus has some adductor action. There need be no fear of the opposite, or abduction deformity.

The nerves to the hamstrings do not leave the sciatic in either definite sizes or at definite levels and this necessitates a complete exposure before any resecting is done, thus obviating the danger of destroying too much or too little of the supply. A four or five inch incision is made in the middle of the back of the thigh, beginning just above the lower border of the gluteus maximus, the dissection is carried through the deep fascia just lateral to the hamstrings under which the sciatic is found. If the entire supply is not readily found, the incision should be carried higher by incising transversely the lower fibres of the gluteus maximus. No harm can be done by this as the rent is easily repaired and what weakness may remain will be advantageous. No difficulty will be experienced in gaining a complete exposure if the incision is made as high as the level of the ischial tuberosity from which the hamstring muscles arise. In severe cases it may be desirable to divide the tendons of these muscles at the knee but this should not be done at the same time for fear of producing a back knee deformity. Recurvatum can be as serious as flexion.

The calf muscle control may be attacked at this site by dissecting the sciatic nerve, the topography of which is practically always constant. The tibial portion is always deep and medial and the fibres are identified with the electric current. This method of procedure, however, is advisable only after considerable experience, the simpler plan being a midline incision in the lower half of the popliteal space between the heads of the gastrocnemius. The scar should be kept below the bend of the knee. The dissection is carried through the deep fascia just beneath which will be found the sensory sural nerve and superficially lying laterally on the heads of the gastrocnemius will be the nerve supply of this muscle. In moderate cases the destruction of this supply is sufficient, but in severe cases part of the supply to the soleus must also be destroyed. It is most often found at a higher level and in many branches proceeding anteriorly from the tibial or medial popliteal nerve which lies in the midline and much more superficially than may be expected. It will have been exposed just under the sural nerve but some confusion may be experienced if the heads of the gastrocnemius are not effectively retracted and kept from rolling toward the midline and clouding the field. In doing this it must be remembered that a calcaneus foot is perhaps more disabling than an equinus and it is therefore better to destroy too little than too much of the control. The former mistake can be rectified but the latter never.

After Stoffel's procedure, exercises and muscle training and even the use of braces, when necessary, will be found more effective and it is to be borne in mind that such post operative care is extremely important if optimum results are to be expected.

FIG. 5

Dissection illustrating obturator nerve dividing over adductor brevis muscle with adductor longus drawn forward and laterally and the gracilis back.

FIG. 6

Dissection illustrating sciatic nerve with branches to the hamstring muscles. The lower border of the gluteus maximus has been divided and the hamstring group retracted medially.

FIG. 7

Dissection illustrating hamstring tendons in the popliteal space with the tibial and common peroneal nerves, the latter in close relation to the biceps. Note that muscle tissue runs very low.

FIG. 8

Dissection illustrating the nerve supply to the gastrocnemius. The heads of origin have been pulled to either side to show nerves lying on them, the tibial nerve deeper in between and the sural nerve quite superficial and retracted to the side.

Gray ramisectomy of the sympathetic system has a place in the treatment of certain of these cases (the ones manifesting plastic tone or lengthening and shortening reactions). The operations are not difficult if a thorough knowledge of the anatomy is possessed.

For the upper extremity an incision is made extending upward from the clavicular head of the sternocleidomastoid, more or less paralleling this muscle, and back along the clavicle if greater exposure seems necessary. The platysma in the superficial fascia is incised and the external jugular vein tied off. By blunt dissection the muscle fascia and then the prevertebral fascia over the scalenus anticus and the scalenus medius and brachial plexus is cleared away. The branches of the cervical plexus and the spinal accessory nerve must be avoided where they swing around the posterior border of the sternomastoid, but this is high enough to be made easily possible. The roots of the brachial plexus frequently pass through the scalenus anterior and medius, instead of between the two muscles, the first two roots being almost certainly in the substance of the former muscle. Since the gray rami of the sympathetic system may be in several branches and may enter the plexus at any point beyond the vertebral foramina, it is imperative that the cords and roots of the plexus be followed into the vertebra in order to be certain that all rami are avulsed. Avulsion is the method used in destroying them. The rami to the eighth cervical and first dorsal roots are exposed with greatest difficulty but if the subclavian vessels are held forward and down and the plexus followed medially until these roots deep beneath the clavicle are defined, the difficulty, in spite of the depth of the wound, will not be found extraordinary. Proximity to the pleura must be remembered. There will be little bleeding if gentleness and blunt dissection in the handling of the tissues are used. All gray rami must be destroyed if a result is to be gained.

In the lumbar region very little difficulty is encountered even though the wound is deep. Suitable retraction, however, must be had and this is best obtained by special instruments, designed by Royle. The operator faces the back of the patient, who has been placed on his side, inclined slightly backwards, across a sandbag. The sandbag or other elevation is necessary because it widens the distance between the crest of the ilium and the ribs and places the trunk wall under tension, thus making an easier dissection. The incision reaches from the twelfth rib vertically down to the crest of the ilium at its highest point and thence forward nearly to the anterior superior iliac spine. Petit's triangle is defined and the muscles of the belly wall cut off the iliac crest. The external oblique should be incised in fascia only, whereas the internal oblique and the transversalis must be removed through muscle fibre. The incision is carried in the lumbo-dorsal fascia up to the twelfth rib, care being taken not to open the sheath of the quadratus lumborum. The iliohypogastric and the ilioinguinal nerves will be encountered but are easily retracted. The properitoneal fat is now exposed and the belly wall and contents drawn forward. A blunt dissection is carried across the quadratus lumborum and then

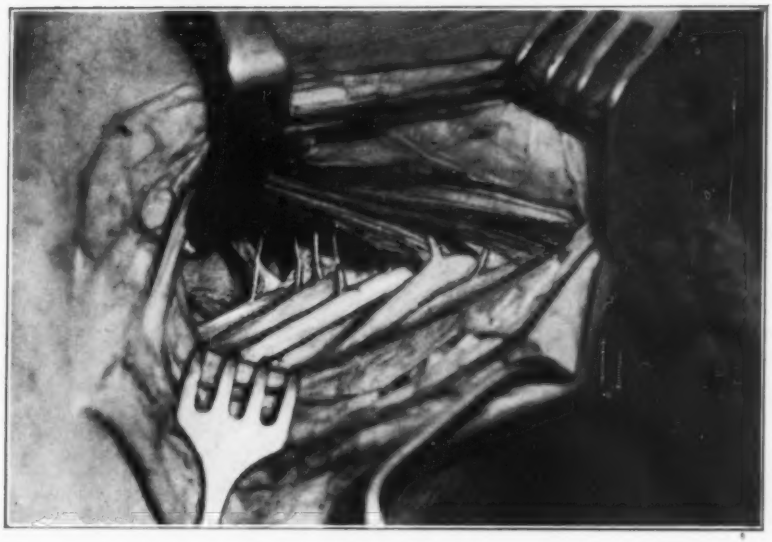

FIG. 9

Dissection illustrating sympathetic rami to the brachial plexus. A part of the scalene mass is drawn forward and the five roots of the plexus with the rami are seen. The rami pass through the muscle mass.

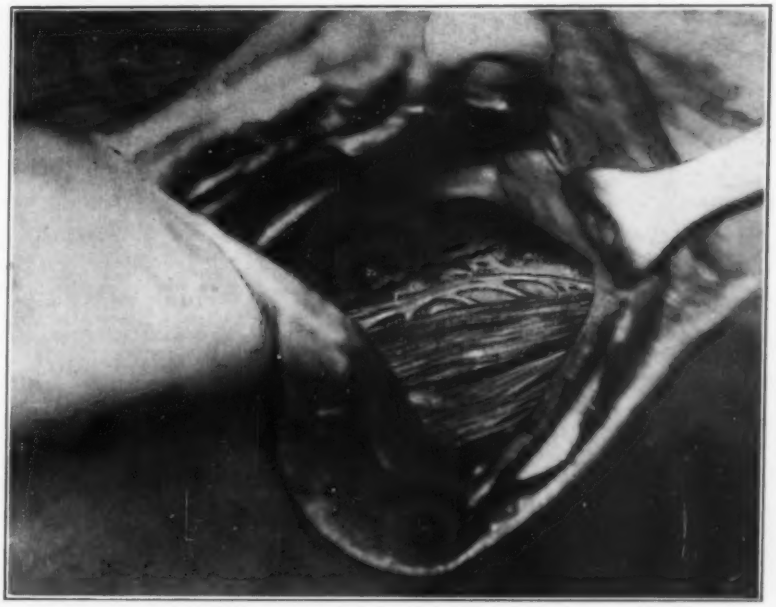

FIG. 10

Dissection illustrating the sympathetic chain in the lumbar region. The abdominal wall with contents within is retracted forward. The anterior border of the quadratus lumborum is seen and the rami are passing laterally into the psoas to reach the roots of the lumbar plexus. The ganglion at the fourth lumbar vertebra is shown and below this the chain is divided.

across the psoas to the vertebral column. Here a fairly tough fascia will be seen spread smoothly across the great vessels, the side of the vertebral column and the psoas itself. Through it, against the bone and just medial to the edge of the muscle the sympathetic chain can be palpated and it should be felt before the fascia is opened in order to avoid confusion and some difficulty in finding it. The chain may be in two or three divisions but after exposure all rami running laterally between the second and fourth lumbar vertebrae must be avulsed and the chain or chains divided at the lower point. A white ramus at the level of the second may be exposed entering the trunk from above and this should not be destroyed. No interference with any function except that desired in the skeletal musculature will be noted following this procedure.

Postoperative muscle training is absolutely essential, the operation not being a cure-all. In properly selected cases with proper follow-up, a definite relief from spasticity will be noted and a marked increase in muscular control will be gained.

In closing, another word for preventive medicine will be added. Sharpe's work on hemorrhage in the new-born is timely and if more attention be paid to this matter at birth, fewer cripples will result and much effort can be saved for constructive work instead of used in the repair of that which never should have been.

TROPHIC OSTEOPATHY

BY E. B. MUMFORD, B.S., M.D., INDIANAPOLIS, INDIANA

The influence of the nervous system upon the nutrition of the tissues of the body is well recognized, not only in certain functional and mental conditions, but more especially in definite organic lesions of the lower neuron tract. The perforating ulcer of locomotor ataxia and spinabifida, the atrophy of muscle and retardation of bone growth in poliomyelitis, the blebs in herpes and in median nerve lesions have all been attributed to loss of the normal physiological nerve influence.

It is not the purpose of this paper to discuss the question of the existence of true trophic nerve fibres. Whatever opinion one may have as to this problem, the fact remains undisputed that a disturbance of the normal physiological function of a nerve, either in its cell or in its trunk and terminal endings, leads to a modification of that tissue supplied by the affected nerve. It is this nutritional change which is termed trophic.

Apparently there is but little knowledge as to the anatomy of the nerve supply of bones. The subject, in reference books, is dismissed with the simple statement that nerves are freely distributed in the periosteum and that they also accompany the nutrient artery into the interior of the bone. Inasmuch as every tissue in the body has some nerve supply, it is reasonable to suppose that the bone cells are not unlike other tissue cells, in that they have nerve influences which have a definite relation to the nutrition of the cell.

The four cases presented in this paper represent definite and distinct bone changes in association with lesions of the lower neuron tract. Inasmuch as the bone change could be accounted for only through a disturbance in the nerve influence it has been termed "trophic osteopathy." To the writer's knowledge this condition has not been heretofore described.

CASE 1. C. G. Age 55, male, white. When a lad he noticed that his left leg was not as strong as his right and in later life there was a difference in the size of the legs, the left being smaller. At this time a more careful examination was made and it was noted that there was a partial paralysis of the group of muscles supplied by the superficial peroneal nerve. This observation was confirmed by another surgeon. At the age of twenty-one he developed a callosity upon the little toe and this toe was amputated. Five years later he developed a callosity beneath the head of the fifth metatarsal. Three or four years later a small amount of clear serum was discharged from beneath this callosity but three weeks of rest healed the lesion. Two years later he was confined to the bed on account of a return of the discharge. The lesion healed and he did not have any more trouble for several years, except that the callosity would reform and at times he would have a slight serous discharge for two or three days. There was never noted any pus nor discharge of bone.

In 1922 he came under my observation for the first time. There was present a slight varus deformity due to a weakness in the peroneal group of muscles. Beneath

the head of the fifth metatarsal bone was a large callosity in the center of which had developed a sinus. This sinus was found to lead down to exposed bone. In December 1922, the fifth metatarsal bone was exposed for removal, a diagnosis of chronic osteomyelitis having been made. At time of operation the metatarsal was found to have lost practically all of its true bony character and was represented by a grayish, red, gelatinous material, which could easily be wiped out with a piece of gauze. Unfortunately the true condition was not recognized and neither bacteriological, pathological nor x-ray study was made. The wound was closed with only a small drain. At the end of two weeks, although the original wound was apparently healed, there developed an extensive cellulitis of the entire foot which required amputation of the leg in the upper third in order to save the life of the patient. The amputation stump healed by first intention and the patient is now wearing an artificial leg. X-ray study at this time did not reveal any pathology in the bones of the foot.

At the time of the amputation conditions were noted in the fibula which led to the study of the second and third cases in this series, which were already under my observation, and to the immediate recognition of the condition in the fourth case at a later date. The fibula instead of being normal bone through which one could easily cut with bone forceps and showing the usual highly vascular medullary canal, was represented by a very hard, brittle bone, in which the vascularity of the canal was entirely gone, being replaced by a hard, chalky substance. The tibia was apparently normal.

Inasmuch as there had never been any symptoms referable to the fibula, this condition could not be explained by any pyogenic infection, nor could its relation to the metatarsal pathology be accounted for either through a blood stream nor through a direct extension process.

Case 2. W. F. Age 25, male, white. December 5, 1919, he fell from a telephone pole. There occurred a dislocation between the twelfth dorsal and first lumbar vertebrae with symptoms of almost complete transverse cord pressure. Examination showed an almost total anaesthesia and an almost complete paralysis of the lower extremities, there being left only a very slight motion in a few of the muscle groups. Loss of control of the rectal sphincter and retention of the urine was present. In January 1920, at the time of my first examination, these symptoms were still present and there had developed a large scrotal abscess, due to extravasation of urine through a fistula in the urethra produced by the catheter. The temperature was 103 degrees, the patient in extreme pain and the case apparently a hopeless one.

February 12, 1920, nine weeks after injury, a laminectomy was done. The cord was found to be compressed for a distance of about one-half inch. The pressure was relieved but the dura was not opened. The patient made a most rapid recovery, the pain being relieved at the end of the second day and at the end of two months a very considerable power had returned in the legs. Later the control of the bowels was regained. The only pathology which remained was a paralysis of the muscles supplied by the superficial peroneal nerve and the necessity for constant bladder drainage. (It may be stated here that this patient is, at the end of six years, in good general health although he has worn constantly a catheter during this period.) Later a varus deformity developed.

In November 1920, ten months after his operation, he developed a callosity beneath the head of the fifth metatarsal of the affected foot. Shortly afterwards pus formed beneath the callosity and was released through an incision. This did not completely heal until he was put at absolute rest, following an attempt to correct the deformity through a Gallie operation. One month after he began to use his foot the pus reappeared. This discharge remained until April 1923, although only in a small amount and without any acute reaction. At this date the sinus healed and has never reappeared. During the period of discharge from the sinus he was treated for an infection of the soft tissues as there had never been any discharge of bone nor any symptoms of an acute osteomyelitis. In December 1923, after the first case had called my attention to a possible bone change, x-rays were made which revealed a marked change in the fifth

FIG. 1. CASE 2

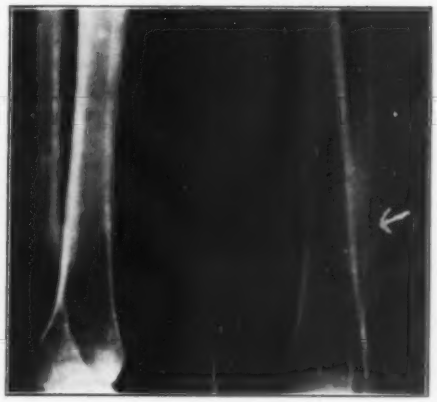

FIG. 2. CASE 2

metatarsal. The report of the roentgenologist at that time was as follows: "Film of lower two thirds of right leg. The tibia shows no bony change, except a possible slight sclerosis. At the junction of the lower and middle thirds of the fibula on the external lateral surface there is a definite loss of bone substance, which involves the cortex and part of the medullary portions of the bone. The appearance is peculiar in that it does not appear as an infectious process but as an atrophic disturbance. There is not any evidence of an inflammatory reaction either in the periosteum nor in the medullary cavity. The right foot shows the same peculiar change in the fifth metatarsal as noted in the fibula. The distal fourth of the shaft with its articular surface seems to have been completely absorbed. The shaft of the bone is pointed, the cortex however being intact. The extreme distal end of the remaining portion of the shaft shows some rarefaction, while the rest of the shaft has a normal density, in fact a greater density than that in the first metatarsal. The phalanges of the fifth toe show some rarefaction but their continuity is retained."

In December 1923, the distal half of the fifth metatarsal was removed. The wound was closed without drains and healed by first intention. The bacteriological report of the specimen was negative for growth. The pathological report was as follows: "Tissue

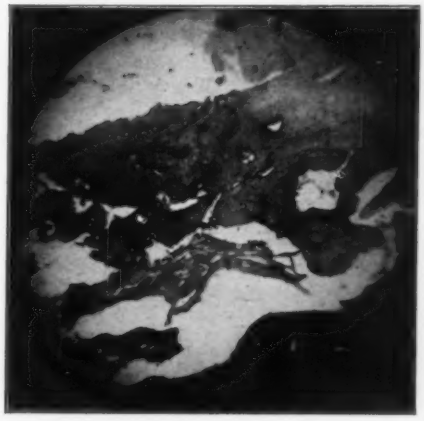

FIG. 3. CASE 2
Section of fifth metatarsal. Low Power.

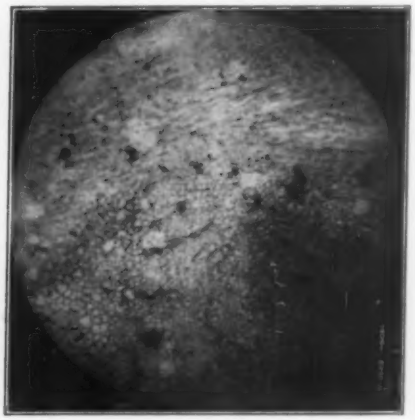

FIG. 4. CASE 2
Section of fifth metatarsal. High Power.

from the fifth metatarsal. There seems to be some absorption of bone salts. None of the cells stain well. The canals run in every direction and are enlarged. In the canals are some leucocytes and in places new fibrous tissue is seen which is quite vascular."

In December 1924, the leg was amputated in the upper third at the request of the patient, who did not desire to have a stabilizing operation with the possibility of an infection. At this operation the same condition was noted in the fibula as was found in the first case. The fibula was hard and brittle and the medullary cavity devoid of any macroscopic blood supply. A study of the fibula and the fifth metatarsal by Doctor Warfel, Indianapolis, shows these bones to "appear normal except for a decrease in the amount of medullary tissue. There is not any evidence of an acute infectious process." The bacteriological report of these tissues was negative for growth.

In this case we also found changes in the fibula which could not be attributed to a pyogenic infection nor could the study in the pathological, bacteriological or x-ray laboratories of the tissue of the fifth metatarsal, find any evidence of infection as the etiological factor.

Case 3. W. E. Age 30, white, male. In October 1918, while in service in France, he received a machine gun wound in which the bullet penetrated the upper third of the left thigh and lodged in the right thigh. There was not any infection but an immediate paralysis of the muscles supplied by the common peroneal nerve was observed. A paralytic foot developed which was corrected by the use of a brace. About two years after the injury there developed a callosity beneath the head of the fifth metatarsal bone of the left foot. Several months later this callosity apparently became infected but healed after four weeks of rest. In October 1922, he had a considerable inflammatory reaction which lasted only a very short time. Following this and up to March 1924, he had numerous recurrences of a discharge from about the callosity but none of a severe type. Since 1924 he has not had any trouble other than the presence of the callosity.

In this case the true condition was not determined but a diagnosis of an infection beneath the callosity was made, as the picture was not that of an osteomyelitis nor was there any sequestration. This patient was a claimant under the Veterans Bureau and it was not until the middle of 1924 that an x-ray of the foot was obtained. The report of this laboratory is as follows: "Left foot. Examination of the left foot shows a generalized osteoporosis, especially in the cancellous portions. The fifth metatarsal shows a pointing at its distal end. Medullary and cortical portion show no signs of irregularity or osteomyelitis but point to a rather sharp spicula-like shadow with the articular surface completely destroyed. The phalanges show a marked atrophy but their contour is distinct."

In this case it will be noted that the fibula does not show any pathology but no doubt if an amputation were done the same changes would be noted in the fibula as were found in the first and second cases. In the second case there was not noted in the x-ray any definite change in the fibula at the site of the amputation but a change was found at time of operation. However, in the fifth metatarsal and also in the phalanges the same absorption was found. The pencil point of the shaft of the metatarsal without much change in the width of the cortex is of especial interest. It certainly is not the typical picture of a pyogenic destruction.

Case 4. J. S. Age 45, white, male. At the age of four his right foot was caught in a mowing machine, causing a compound fracture of the fibula with a complete severance of the peroneal tendons about three inches above the external malleolus. The wound became infected and several large pieces of bone sequestrated. A chronic osteomyelitis persisted for a period of thirty years, the wound having been healed the past ten years.

Following the accident the foot gradually became deformed until the present condition of extreme varus was reached. About six years after the accident a callosity developed beneath the head of the fifth metatarsal and two years later it apparently became infected and a discharge appeared. This condition would persist for about a week and occurred about three times a year. During the past ten years there have

FIG. 5. CASE 3

FIG. 6. CASE 4

appeared, about twice a year, numerous blebs over the dorsum and external aspect of the foot. These blebs remain for a period of four to five weeks and during this time the foot is swollen, red and painful. There has never been any bone discharged from the sinus beneath the fifth metatarsal.

At the time of the examination in August 1924, the foot was swollen, red and tender and numerous blebs, about one-quarter of an inch in diameter, were on the dorsum and external surfaces of the foot. There was a condition of marked varus with considerable cavus deformity. Beneath the head of the fifth metatarsal was a large thick callosity with a small discharging sinus. There was also a similar sinus between the heads of the fourth and fifth metatarsals which he stated came about four years before. Examination six months later showed a normal skin so far as any inflammatory reaction or any bleb formation. The sinuses were also healed.

The report from the x-ray laboratory was as follows: "Left foot—considerable deformity of toes. The distal phalanges of the third and fourth toes are intact, but represented by a very faint shadow, due to almost complete atrophy. The distal phalanx of the fifth toe has been completely absorbed. The proximal phalanx of the third toe shows a marked atrophy, leaving a sharp spike-like process. The proximal phalanx of the fourth toe is similar to that of the third toe. The proximal phalanx of the fifth toe shows a similar but more marked atrophy. The fifth metatarsal shows a destructive irregular process involving the distal two thirds of the shaft; both cortical and medullary portions of the bone on the inner aspects. A similar process involves the distal articular surface of the fourth metatarsal. In both fourth and fifth metatarsals there is distinct evidence of a destructive osteitis. The condition in the metatarsals and especially in the phalanges do not represent a change in the bone as characteristic of a pyogenic process."

In this case the pathology was recognized at the time of the first examination. It is noted there is not any change in the fibula nor would one expect to find any change as the lesion to the nerve was at a very low level. Although one finds in the bones of the foot the same absorption as exists in the other cases, it is also to be observed that the change affects the fourth as well as the fifth metatarsal. There is also to be observed, in this case, evidence of an osteomyelitis in these two bones, the shafts being thickened and irregular in their outline. It may be assumed that here we have not only the nutritional changes following the nerve lesion but also an osteomyelitis of a mild type which resulted from an infection through the sinus. However it must be noted again that there was no history of sequestration.

In a consideration of these cases as a whole several things are to be noted. All represent an involvement of those nerve elements which make up the superficial peroneal nerve. Not only is the etiological factor different in each case, but the level of the lesion is also different. The first case followed an anterior poliomyelitis and therefore was a cord lesion involving the nerve cells. The second case resulted from a dislocation between the twelfth dorsal and first lumbar with pressure upon the cord, which may have affected the nerve cells or the roots. The third case, that of a bullet wound through the thigh, injuring the trunk of the sciatic nerve; while in the last case, which was caused by a deep cut, the branch of the nerve alone was involved, the paralysis of the foot being due to the cutting of the tendons, rather than to the loss of nerve supply to the muscles.

It will also be noted that in each case there was the slow formation of a callosity beneath the fifth metatarsal which was later complicated by a discharging sinus, with a discharge of pus but never at any time any sequestration. In two of the cases in which x-ray study was made there has been an absorption of the bony tissue without any evidence of an osteitis or an osteomyelitis. In the two cases which had amputation there was noted a very marked change in the fibula.

At first thought one might conclude that the bone changes are the result of a low grade infection occurring through the sinus about the callosity. The discharge of pus, the chronicity of the case with intervals of complete healing and the loss of bone would support this view. However, it does not explain the changes found in the fibula in the amputation cases, nor is the x-ray picture typical of an osteomyelitis. The picture in the second and third cases is that of absorption of bone tissue without any of the characteristic points of an osteomyelitis. In the fourth case there is in the metatarsal bones some mottling and thickening of the shaft but the phalanges show no evidence of a pyogenic infection, and are thus similar in their changes to that found in the second and third cases. In the second case we also had a sterile tissue in the bone as shown by the "no growth" report from the laboratory.

It is the writer's opinion that the only plausible explanation for the bone changes in these four cases must be based upon some disturbance in the nervous nutritional influences and not upon a pyogenic infection.

Every case of paralysis of the superficial peroneal nerve in which a callosity develops beneath the fifth metatarsal should be carefully studied for any bone change, a change which can be termed "trophic osteopathy".

UNUNITED FRACTURES WITH SPECIAL REFERENCE TO THE CHEMISTRY OF THE BLOOD*

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Many hypotheses have been evolved to explain the processes at work in ossification. Some investigators maintain that the process is a simple chemical one, others explain it on the basis of the elective affinity of the cell, and still others believe it is biochemical in origin and due to enzyme action. Theories of chemical changes are based on a series of papers published in 1857 by Rainey on the precipitation of calcium carbonate and calcium phosphate from colloids. Recently these experiments have been confirmed and amplified by Watt, who, like Wells, accepts the idea of Barillé that the calcium of the blood exists as a soluble complex double salt, tribasic calcium-carbonophosphate: $P_2O_8Ca_2H_2$: 2 CO_2 $(CO_3H)_2Ca$. This, he believes, explains the constancy of the composition of all types of bone by bringing to it the two salts in exactly the proper proportions. From this stage onward Watt differs from Wells in that the former maintains that this salt is taken from the blood and deposited in the bone by the action of osteoblasts as formerly suggested by Klotz and by Röhmann (a vitalistic philosophy) while Wells believes that it is due to a shift in the hydrogen ion concentration by a change in the carbon dioxid content (a purely mechanistic conception).

The experimental work of Pfaundler, of Pauli and Samec and of Freudenberg and György resulted in a number of theories, with elective affinity as their bases. Pfaundler placed pieces of cartilage in the abdominal cavities of animals and found that their power (Kalksalzfänger) of taking up calcium was thus increased, but that all varieties of cartilage did not have the same affinity for calcium. Epiphyseal cartilage, for example, was able to take up much more calcium than costal or tracheal cartilage. He concluded that a substance was secreted from the bone-cell or cartilage-cell at a certain stage of development, which caused the surrounding tissue to assume a specific affinity for the calcium salts of the blood. Pauli and Samec demonstrated that the tissue fluids that contain a greater proportion of proteins are capable of taking up more calcium, and they believe that the impregnation of cartilage with lime salts is due to the high content of protein in the cartilaginous ground-substance. Freudenberg and György in a series of experiments put cartilage, which had been previously treated

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with a solution of calcium chlorid, into a solution of phosphate and observed bony changes in the cartilage; however, if they put the cartilage first into a solution of phosphate and then into a solution of calcium chlorid, no bony change resulted. From this they concluded that the mechanism of ossification was not purely chemical, as the reaction was not reversible.

Robison, in 1923, presented interesting evidence which suggests the presence of an enzyme in the bones and ossifying cartilage of young animals, which rapidly hydrolyzes phosphoric esters with the liberation of free phosphate ions. This work has recently been amplified and extended by Robison and Soames. Their conclusion is that an enzyme (a monophosphoric esterase) is present in ossifying cartilage, growing bone and teeth, but to a less extent after the animals become fully grown. This enzyme is assumed to act on and hydrolyze the phosphoric esters (hexosemonophosphoric acid and glycerophosphoric acid) in the blood, and liberate phosphate ions in the immediate neighborhood of the site of ossification. Consequently, the product of the concentration of the phosphate and calcium ions becomes greater than the solubility product of calcium phosphate, and this is deposited in a solid state. As further evidence, these investigators demonstrated that calcium phosphate is deposited in vitro in bone taken from rachitic animals when it is immersed in a solution of suitable phosphoric esters.

Howland, in his discussion of bone-formation in his Harvey Lecture of 1923 on the pathogenesis of rickets, puts in more concrete form the physicochemical theories of Wells on ossification, and the reader is referred to their papers for a full exposition of the subject. The theory is based on the fact that the precipitation of salts in solution follows the well-known law of mass action and can be predicted from the so-called solubility-product constant which is different from, but characteristic of, each salt. The solubility-product law under the most simple conditions may be stated as follows: in sufficiently dilute solutions saturated with a slightly soluble univalent salt the product of the concentrations of the ion species of that salt is constant. For example, the product of the ionic concentrations of silver and chlorin divided by the concentration of the molecular silver chlorid is a constant which cannot be exceeded without precipitation. Unfortunately in the blood we are not dealing with simple univalent salts in pure water but with salts of higher valence in solution equilibrium in an exceedingly complex solvent. Furthermore, variations in the ionic concentrations of calcium and phosphorus in the serum cannot be measured in clinical work and hence a true solubility constant cannot be determined. In spite of these difficulties, Howland believes that information of value to the clinician can be deduced from a rough product obtained by using as approximate factors the total concentration of calcium and phosphorus in the serum. He based the possible value of such a product upon experiments carried out in conjunction with Marriott and Kramer. They showed that a precipitate consisting largely of tricalcium phosphate with some carbonate is formed when the hydrogen ion concentration is increased by

reducing the carbon dioxid tension in an artificial serum, if the product of the concentration of calcium and phosphate present (in milligrams for each 100 c.c.) exceeds 40. Howland visualized the mechanism of bone formation as follows: "Serum contains calcium and inorganic phosphorus in solution in much higher concentration than water would hold them, on account of the high CO_2 tension. There is some evidence to show that part of the calcium is bound to protein. If it is assumed that this calcium-protein compound is poorly ionized this would be equivalent to reducing the total calcium concentration. Intercellular fluid of the tissues contains roughly the same amount of calcium and phosphorus, according to our determinations, as the serum, but the protein is much less, apparently about 1 per cent., as contrasted with 7-9 per cent., in the serum. The CO_2 tension is relatively high on account of cellular activity. But supposing that the CO_2 tension is low because the tissue is inactive or dead, then conditions are favorable for precipitation. Cartilage and the trabeculae of bone are both inactive tissues and it is in them that one would expect the CO_2 tension low and it is in them that precipitation takes place.

"This view of the factors that control calcification and of the mechanism of calcification, explains the normal process and the failure in rickets and tetany of children and the rickets of animals. It also explains calcification in dead or inactive tissues such as tuberculous lesions and in the fascial planes of the muscles in myositis ossificans, where the first change seems to be a hyaline transformation of the connective tissue. What is further of much importance, it explains the constancy of composition of the bones of all animal species in which the calcium and inorganic phosphorus concentrations of the serum so far as they have been studied do not differ greatly from those of man."

Putting this theory to the test, Howland found that in rickets when the product was above 40 either demonstrable healing was taking place or the patient did not have rickets; that with products between 30 and 40 rickets was usually present; and that when the product was below 30 rickets was invariably present.

Petersen, in 1924, applying the work of Howland and Kramer on rickets, studied the calcium and phosphorus in the serum in cases of ununited fracture and used normally healing fractures to control his results. He studied nine normal cases and nine cases of nonunion, and used, as his index of ability to unite, the same value of the product which Howland had found indicative of the presence or absence of rickets in children. Petersen's evidence is confirmatory of the idea that union of a fracture was not likely to occur if the product was less than 30, that little healing would occur if it was between 30 and 35, and that active healing would be more frequent if it were between 35 and 40. He was of the opinion that in cases of ununited fracture there is a constitutional disturbance causing a reduction of the concentration of calcium and phosphorus below normal, and that the normal concentration can be restored by diet and drugs. Later in the same year he published the results of experiments on animals

and drew the same conclusions as in his study on fractures in man. Tisdall and Harris, on the other hand, had laid more stress on local metabolic factors at the site of fracture. They found that, in the adult, only when bone is being formed as the result of a fracture does the phosphorus content reach the level maintained during the period of normal bone-growth in the young.

Recent studies on the chemistry of the blood have produced many estimations of the content of calcium and inorganic phosphate. These are expressed in milligrams of calcium and phosphorus for each 100 c.c. of serum or plasma; whether the serum or plasma is used makes little practical difference. The serum calcium in health is singularly constant in all mammals, including man, but shows slight variations with age. The usually accepted figure for serum calcium is 10 mg. for each 100 c.c. plus or minus 1 mg. with a tendency, as shown by Kramer, Tisdall and Howland, for it to run between 10 and 11 mg. in children. Rona and Takahashi showed that part of the calcium of serum was nondiffusible and, therefore, presumably in combination with protein. From the solubility constant of calcium carbonate under similar conditions they calculated that the ionized calcium in serum would not be far from 2.2 mg. Brinkman and van Dam obtained a similar figure. For clinical studies, however, we must limit ourselves to a knowledge of the total calcium present in the serum.

The inorganic phosphate (expressed as phosphorus) in the serum or plasma is not as constant as the calcium and varies relatively more between the child and the adult. Tisdall and Harris found, in children from the fourth month to the eighteenth year, an average of 5.4 mg. of phosphorus in 100 c.c. of serum, and in adults from twenty to forty-four years, 3.8 mg. Anderson gives an average of 4.8 mg. for children up to twelve years and 3.3 for adults. In our series of examination we found an average of 4.2 mg. for children and 3.4 mg. for adults. The estimation of inorganic phosphate is somewhat tricky partly because the amount obtained, after the blood has been allowed to stand too long in contact with the clot, is usually considerably increased, probably by hydrolysis or organic phosphorus compounds diffusing out from the corpuscles. It is, therefore, necessary to standardize the time between the taking of the blood and the estimations. Maitland and Robison found that after the blood had been laked with distilled water, the amount of inorganic phosphate in whole blood increased rapidly, as much as 10 per cent. in five minutes and 50 per cent. in two hours at room temperature. At 37° C. the increase was considerably greater. In the presence of 1 per cent. of trichloracetic acid no increase occurred at all in two hours at 37° C. In unlaked blood at room temperature, these investigators found only a slight increase in six hours, but experiments reported by Kay and Robison show that when unlaked blood is kept for five hours at 37° C. the amount of inorganic phosphate in the plasma is increased about 20 per cent. In a control series we have found, like Howland and Kramer, that the increase during the first six hours was slight even when the serum was allowed to stand in contact with the clot; if,

however, under the latter conditions, twenty-four hours elapsed, the amount obtained was from 60 to 100 per cent. greater.

Alterations in the calcium and phosphorus content of the blood can be produced in several ways. Binger showed that the intravenous injection of orthophosphates of sodium into dogs at the right reaction and in amounts of 150 mg. for each kilogram of body weight, caused the serum calcium to drop from 10 to 6 mg. for each 100 c.c. and was accompanied by a condition of tetany. The tetanic state caused by the phosphate is, according to Binger, not dependent on the drop in calcium alone but also varies with the degree of alkalinity of the solution used. On the other hand Salveson, Hastings, and McIntosh, in a recent extensive study of the subject, found that large doses of phosphate, administered over a period of one or two days, produced marked tetany independently of the hydrogen ion concentration of the solution used; they concluded that the clinical symptoms of tetany, produced by the oral administration of phosphate, are due to a decrease in blood calcium.

The results of feeding calcium in excess to animals are somewhat variable. Some investigators find an increase in the plasma calcium, but a decrease in the plasma phosphorus. In like manner, excess phosphorus in the diet raises the concentration of phosphorus in the plasma. McCollum, Simmons, Shipley and Park found that when a diet high in calcium and low in protein is fed to rats, absorption of calcium is improved and that of phosphorus is impaired. Howland and Kramer, also studying rats on this diet, observed that the concentration of calcium in the serum is raised and that of inorganic phosphorus lowered. Salvesen, Hastings, and McIntosh considered that calcium chlorid given orally is the most effective salt. The administration of calcium salts to man, by mouth or hypodermically, may correct deficiency in calcium but cannot materially raise the calcium content above normal. There is never a deficiency of lime salts in a normal diet. If hypocalcemia exists, the cause must either operate in the gastro-intestinal tract to prevent absorption, or depend on excessive elimination in the urine or feces, on some condition in the tissues which facilitates absorption of calcium from the blood stream, or on the deficiency of some hormone (parathyroid) in the blood stream whose presence is essential for a normal content of blood calcium. Orr has shown that the absorption of both calcium and phosphorus from the intestine is hampered by diet which increases the alkalinity of the stools. Calcium salts appear to exist in the blood in a saturated solution and this is dependent on the hydrogen ion concentration and the carbon dioxid tension of the blood. It has been shown that cod-liver oil and ultra-violet rays assist in maintaining the proper concentration and utilization of both calcium and phosphorus. Collip has demonstrated that by the use of the parathyroid extract prepared by him the blood calcium can be more than doubled by repeated subcutaneous injections at short intervals; this is the only substance that will materially increase the blood calcium above normal.

We have carried out quantitative estimations* of the calcium and phosphorus in the blood of a considerable number of patients with ununited fracture. For many reasons it is not always possible in a busy surgical service to follow up the case and compile sufficient readings suitable for publication. In addition to this incomplete data we have twenty cases of typical ununited fracture in which one blood examination was made before operation and at least two determinations after operation (Table 1). The accompanying tables give the percentages of calcium and phosphorus and the products of the figures. As controls we have listed a series of eighteen cases of chronic eczema (Table 2), in each of which at least two similar tests were made; the averages were for calcium 10.3 mg., phosphorus 3.1 mg., and the product 31.9. The average preoperative readings for the twenty cases of ununited fracture were: calcium 10.2 mg., phosphorus 3.3 mg., product 33.7. The postoperative determinations made within thirty days were: calcium 9.8 mg., phosphorus 3.6, product 35.3; the observations between thirty and sixty days were: calcium 10.0 mg., phosphorus 3.4, product 34.0 and those over sixty days were: calcium 10.2 mg., phosphorus 3.1 and product 31.6. It will be noted that the average of the early postoperative calcium determinations was slightly lower and of the phosphorus slightly higher than the preoperative, and that the increase in phosphorus resulted in a slightly higher product. The individual variations, however, are within the experimental error of the method and are no greater than those found in our control series.

In one case of fracture of the tibia, with a persistently high reading for phosphorus, union was very rapid. When the readings for phosphorus were persistently low, union progressed slowly, and it was evident that metabolism of bone was sluggish. Of the twenty cases presented, union occurred in fifteen after operation, in two it did not, and three are still under observation, in one of which union will probably occur without further difficulty. In the two cases of nonunion, in which union failed, both the phosphorus and calcium were either equal to or on the high side of the average before operation. In one case there was a slight decrease below normal in the phosphorus, resulting in a slightly lowered product. In the other there was a decrease in the calcium with an elevation of the phosphorus, resulting in a slightly decreased product immediately after operation. Six months later, however, the product had returned to above the original level but there was a subsequent drop toward the end of the year.

* The calcium was determined by the Kramer and Tisdall method and the inorganic phosphate by the Bell and Doisy method. In clinical laboratories errors in the calculation of serum calcium frequently arise from contamination of the syringe or tube with the calcium of the water used in boiling or cleaning; therefore, the blood was collected in a syringe which had been boiled in double distilled water and was placed in tubes which had been previously washed with hot cleaning solution, rinsed with distilled and redistilled water, and then dried in hot air. The serum was obtained at once by centrifuging and the calcium precipitated directly as calcium oxalate. The serum protein was immediately precipitated by trichloracetic acid and the filtrate thus obtained was used for the determination of the inorganic phosphate. Daily blanks for calcium were made and the proper correction determined; phosphorus blanks were run at frequent intervals and found negligible.

TABLE 1.

CALCIUM AND INORGANIC PHOSPHATE OF THE BLOOD IN TWENTY CASES OF UNUNITED FRACTURE

Case	Age	Diagnosis	Preoperative			Elapsed days	Postoperative			Operative result
			Calcium	Inorganic phosphate	Product		Calcium	Inorganic phosphate	Product	
1.	21	Nonunion femur	10.6	2.7	28.6	44	10.4	3.3	34.3	union
			10.6	2.8	29.7					
2.	22	Nonunion humerus	9.6	4.0	38.4	21	9.9	4.0	39.6	union
						33	10.1	3.4	34.3	
3.	23	Nonunion tibia	9.8	2.6	25.5	169	9.6	3.1	29.8	union
			10.1	3.0	30.3					
4.	23	Delayed union left femur	12.8	3.6	46.1	61	10.8	3.0	32.4	under observation
						74	10.6	2.9	30.7	
		Nonunion right femur				89	10.3	2.7	27.8	
5.	25	Nonunion femur	10.7	3.6	38.5	11	9.4	2.3	21.6	union
						20	10.3	3.5	36.1	
6.	27	Nonunion humerus	9.3	3.0	27.9	14	10.4	3.1	32.2	union
						25	9.8	2.9	28.4	
						33	9.2	3.0	27.6	
7.	27	Nonunion humerus	10.0	3.4	34.0	7	10.4	2.9	30.2	union
						31	9.9	3.9	38.6	
*8.	30	Nonunion femur	10.3	3.7	38.1	30	10.5	2.8	29.4	no union
						37	9.5	3.1	29.5	
9.	33	Nonunion humerus	9.5	4.2	39.9	29	10.8	3.6	38.9	union
						41	10.9	4.1	44.7	
10.	35	Nonunion radius	9.2	3.6	33.1	11	9.9	3.3	32.7	union
						23	10.3	3.0	30.9	
11.	35	Delayed union tibia	9.2	2.8	25.8	44	10.4	3.8	39.5	union
						55	10.5	3.0	31.5	
12.	37	Delayed union tibia	10.0	2.6	26.0	17	9.8	3.1	30.4	union
			10.1	2.8	28.3					
13.	39	Delayed union tibia	11.5	5.0	57.5	12	9.8	4.4	43.1	rapid union
			11.5	4.4	50.6					
			10.6	5.5	58.3					
14.	44	Nonunion tibia	11.5	2.3	26.5	13	10.5	3.0	31.5	union
						38	10.1	2.8	28.3	
15.	47	Nonunion radius and ulna	11.4	3.1	35.3	28	10.2	4.1	41.8	union
						52	9.8	3.5	34.3	
*16.	52	Nonunion humerus	10.7	3.2	34.2	39	9.0	3.5	31.5	no union
						197	9.8	3.6	35.3	
						331	10.3	3.0	30.9	
17.	55	Nonunion femur	9.9	3.0	29.7	24	9.8	3.2	31.4	union
			9.7	3.4	33.0	52	9.6	3.1	29.8	
18.	55	Delayed union humerus	10.4	2.7	28.1	47	10.9	3.4	37.1	union
			10.6	3.2	33.9					
19.	61	Nonunion radius and ulna	10.0	4.8	48.0	24	9.4	4.2	39.5	union
						32	9.6	3.2	30.7	
20.	64	Delayed union tibia	7.7	3.4	26.2	2	7.7	6.4	49.3	probable union
						3	7.7	5.5	42.4	
						7	8.6	3.8	32.7	
		Preoperative average	10.2	3.3	33.7					
		Postoperative average 0 to 30 days					9.8	3.6	35.3	
		Postoperative average 31 to 60 days					10.0	3.4	34.0	
		Postoperative average 61 days and over					10.2	3.1	31.6	

*In these cases union did not occur within a reasonable time after operation.

Although our data lend no support to the clinical value of blood calcium and phosphorus determinations in the routine treatment of delayed union, as seen in a general orthopaedic clinic, yet we wish to point out that they do not thereby invalidate the underlying theory that bone-formation is at least in part dependent on a physicochemical mechanism. One factor to remember in this connection is that our cases are all in adults and that normally the amount of phosphorus in the serum is less than in children and also varies under different conditions to a lesser degree; therefore, one can hardly anticipate that the clinical solubility-product will have the same significant values as found in children suffering from rickets. With this decrease in maximal variability in adults the possible significant variations may well decrease to within the limits of the experimental errors of the determination themselves, to say nothing of the errors in the solubility

TABLE 2

CALCIUM AND INORGANIC PHOSPHATE OF THE BLOOD IN EIGHTEEN CASES OF CHRONIC ECZEMA

Case	Age	Calcium	Inorganic phosphate	Product	Case	Age	Calcium	Inorganic phosphate	Product
1.	17	10.4	2.9	30.2	10.	56	10.8	2.3	24.8
		11.1	3.0	33.3			9.7	2.5	24.3
2.	24	10.8	3.0	32.4	11.	59	10.6	3.4	36.0
		11.0	2.9	31.9			10.9	3.6	39.2
3.	25	10.8	3.7	40.0	12.	59	10.7	2.9	31.0
		10.0	3.7	37.0			10.2	3.1	31.6
							10.5	3.1	32.6
4.	29	9.9	3.1	30.7					
		10.9	3.2	34.9	13.	62	10.7	3.0	32.1
							10.4	3.0	31.2
5.	41	10.0	2.5	25.0					
		10.3	2.7	27.8	14.	63	9.7	3.5	34.0
							10.1	3.7	37.4
6.	47	10.6	2.8	29.7					
		10.0	3.3	33.0	15.	63	10.1	3.0	30.3
		10.8	3.4	36.7			10.4	2.8	29.1
7.	50	10.1	3.4	34.3	16.	66	10.0	3.6	36.0
		10.6	3.6	38.2			10.0	3.6	36.0
							10.3	3.1	31.9
8.	52	10.6	2.8	29.7			10.3	3.7	38.1
		10.8	3.0	32.4					
		9.7	3.1	30.1	17.	72	10.4	2.7	28.1
							10.0	3.7	37.0
9.	55	9.8	2.8	27.4			10.5	3.0	31.5
		9.7	3.2	31.0					
		10.6	3.2	33.9	18.	78	10.0	3.0	30.0
							9.6	2.3	22.1

Average calcium = 10.3 Average inorganic phosphate = 3.1 Average product = 31.9

constant obtained by using the total concentration of these substances. As Howland pointed out, it was finally possible to harmonize the views in regard to the etiology of rickets of those who believed the disease due to a deficiency of some particular vitamin in the diet and of those who thought that it was due solely to environmental factors such as sunlight, and so forth. It seems unlikely that bone-formation is solely a question of physical chemistry. We are too imbued with the philosophy of Haldane to deny an important rôle to the bone-forming cells themselves; whether or not the cells work by the production of a specific enzyme is immaterial although its positive demonstration may be anticipated. However, as orthopaedic surgeons, we must treat in a practical manner the ununited fractures that come to our attention. While we may not be able in a given case to demonstrate the value of calcium and cod-liver oil, nevertheless, as they certainly can do no harm, we must use them on theoretic grounds in conjunction with an otherwise well-balanced nourishing diet; the use of sunshine as well as artificial light must also not be neglected especially in cases that prove obstinate to operative treatment. As surgeons we cannot fail to be impressed with the importance of a proper approximation of the fragments by surgical procedures when necessary and by methods which cause as little local injury as possible.

SUMMARY

The failure of a fracture to unite is difficult to explain. That it may in certain instances be due to constitutional causes is hardly to be doubted. Investigation to determine this factor is to be commended and constitutional methods of treatment should be used as a routine in addition to surgical methods. Study of the calcium and phosphorus content of the blood, if carried out from the investigative standpoint, may prove of value in the future although in routine work it rarely leads to information of clinical value. Successful treatment of the average run of ununited fractures is in the great majority of cases a surgical problem and depends much more frequently on correct surgical technic than on methods directed toward overcoming the as yet unknown constitutional or chemical factors concerned in ossification.

BIBLIOGRAPHY

1. Anderson, Grace H.: The Calcium and Phosphorus Content of the Blood in Normal and Rachitic Children. Brit. J. Child. Dis., XXI, 33–48; 107–119, 1924.
2. Barillé, A.: De l'action de l'acide carbonique sous pression sur les phosphates métalliques, combinaison (carbonophosphates) ou dissolution, applications diverses. J. de pharm. et de chim., XIX, 14–71; 196; 245; 295, 1904.
3. Barillé, A.: Rôle des constituants de la dissociation de la carbonophosphate tricalcique dans la génese du tissue osseux et des diverses concretions à base de phosphate et de carbonate de calcium. J. de pharm. et de chim. L, 342–346, 1910.
4. Bell, R. D., and Doisy, E. A.: Rapid Colorimetric Methods for the Determination of Phosphorus in Urine and Blood. J. Biol. Chem., XLIV, 55–67, 1920.
5. Binger, C.: Toxicity of Phosphates in Relation to Blood Calcium and Tetany. J. Pharmacol. and Exper. Therap., X, 105–120, 1917–1918.

6. Brinkman, R. and van Dam, E.: Proc. Kon. Akad. v. Wetensch., Amsterdam, XXII, 762, 1920.
7. Collip, J. B.: The Extraction of a Parathyroid Hormone which will Prevent or Control Parathyroid Tetany and which Regulates the Level of Blood Calcium. J. Biol. Chem., LXIII, 395–438, 1925.
8. Freudenberg, E. and György, P.: Der Verkalkungsvorgang bei der Entwicklung des Knochens. Ergebn. d. inn. Med. u. Kinderh., XXIV, 17–28, 1923.
9. Halverson, J. O., Mohler, H. K. and Bergeim, Olaf: The Calcium Content of the Blood Serum in Certain Pathological Conditions. J. Biol. Chem., XXXII, 171–179, 1917.
10. Henderson, M. S.: Pseudarthrosis of the Tibia in Children. J. Bone & Joint Surg., VII, 340–354, Apr. 1925.
11. Henderson, M. S.: Ununited fractures. J. Am. Med. Assn., LXXXVI, 81–86, 1926.
12. Hess, A. F. and Gutman, P.: The Cure of Infantile Rickets by Sunlight as Demonstrated by a Chemical Alteration of the Blood. Proc. Soc. Exper. Biol. & Med., XIX, 31–34, 1921–1922.
13. Hofmeister, Franz: Über Ablagerung und Resorption von Kalksalzen in den Geweben. Handb. d. Biochem., III, 429–453, 1910.
14. Howland, John: The Etiology and Pathogenesis of Rickets. Harvey Lectures. Philadelphia, Lippincott, XVIII, 189–216, 1922–1923.
15. Howland, John and Kramer, Benjamin: Calcium and Phosphorus in the Serum in Relation to Rickets. Am. J. Dis. Child., XXII, 105–119, 1921.
Factors which Determine the Concentration of Calcium and of Inorganic Phosphorus in the Blood Serum of Rats. Johns Hopkins Hosp. Bull., XXXIII, 313–317, 1922.
Factors Concerned in the Calcification of Bone. Proc. Am. Pediat. Soc., XXXIV, 204–208, 1922.
16. Howland, John and Marriott, W. McK.: Observations upon the Calcium Content of the Blood in Infantile Tetany and upon the Effect of Treatment by Calcium. Quart. J. Med., XI, 289–319, 1918.
17. Kay, H. D. and Robison, Robert: Part III. The Action of Bone Enzyme on the Organic Phosphorus Compounds in Blood. Biochem. Jour., XVIII, 755–764, 1924.
18. Klotz, Oskar: Studies upon Calcareous Degeneration. I. The Process of Pathological Calcification. J. Exper. Med., VII, 633–675, 1905.
19. Kramer, Benjamin and Tisdall, F. F.: A Simple Technique for the Determination of Calcium and Magnesium in Small Amounts of Serum. J. Biol. Chem., XLVII, 475–481, 1921.
20. Kramer, Benjamin, Tisdall, F. F., and Howland, John: The Clinical Significance of Calcium Concentration in the Serum of Children and Possible Errors in its Determination. Am. J. Dis. Child., XXII, 560–564, 1921.
21. McCollum, E. V., Simmonds, Nina, Shipley, P. G. and Park, E. A.: Studies on Experimental Rickets. XVI. A Delicate Biological Test for Calcium-depositing Substances. J. Biol. Chem., LI, 41–49, 1922.
22. Martland, Marjorie and Robison, Robert: Note on the Estimation of Phosphorus in blood. Biochem. Jour., XVIII, 765–768, 1924.
23. Orr, W. J., Holt, L. E., Jr., Wilkins, L. and Boone, F. H.: The Calcium and Phosphorus Metabolism in Rickets with Special Reference to Ultraviolet Ray Therapy. Am. J. Dis. Child., XXVI, 362–372, 1923.
24. Park, E. A., Guy, Ruth A. and Powers, G. F.: A Proof of the Regulatory Influence of Cod Liver Oil on Calcium and Phosphorus Metabolism. Am. J. Dis. Child., XXVI, 103–111, 1923.
25. Pauli, W. and Samec, M.: Ueber Löslichkeitsbeeinflussung von Electrolyten durch Eiweisskörper. Biochem. Ztschr., XVII, 235–256, 1909.
26. Petersen, H. A.: A Clinical Study of Ununited Fractures with Special Reference

to the Inorganic Bone-forming Elements in the Blood Serum. J. Bone & Joint Surg., VI, 885–901, Oct. 1924.

27. Pfaundler, Meinhard: Über die Elemente der Gewebsverkalkung und ihre Beziehung zur Rachitisfrage. Jahrb. f. Kinderheilk., LX, 123–177, 1904.
28. Rainey, George: Quoted by Watt.
29. Rainey, George: On the Formation of the Skeletons of Animals, and Other Hard Structures formed in Connection with Living Tissues. Brit. and Foreign Med. Chir. Rev., XX, 451–476, 1857.
30. Robison, Robert: The Possible Significance of Hexosephosphoric Esters in Ossification. Biochem. Jour. XVII, 286–293, 1923.
31. Robison, Robert and Soames, Katharine M.: Part II. The Phosphoric Esterase of Ossifying Cartilage. Biochem. Jour., XVIII, 740–754, 1924.
32. Röhmann: Quoted by Freudenberg and György.
33. Rona, P. and Takahashi, D.: Beitrag zur Frage nach dem Verhalten des Calciums im Serum. Biochem. Ztschr., XLIX, 370–380, 1913.
34. Salvesen, H. A., Hastings, A. B. and McIntosh, J. F.: Blood Changes and Clinical Symptoms Following Oral Administration of Phosphates. J. Biol. Chem., LX, 311–326, 1924.
35. Schwarz, R., Eden, R. and Herrmann, E.: Über die chemischen Vorgänge, bei der Frakturheilung und deren Beeinflussung. Biochem. Ztschr., CXLIX, 100–108, 1924.
36. Tisdall, F. F.: A Note on the Kramer-Tisdall Method for the Determination of Calcium in Small Amounts of Serum. J. Biol. Chem. LVI, 439–441, 1923.
37. Tisdall, F. F. and Harris, R. I.: Calcium and Phosphorus Metabolism in Patients with Fractures. J. Am. Med. Assn., LXXIX, 884–887, 1922. A Note on the Phosphate Content of the Serum of Cases of Bone Tuberculosis Treated by Heliotherapy. Can. Med. Assn. J., XIII, 177–178, 1923.
38. Watt, J. C.: The Behavior of Calcium Phosphate and Calcium Carbonate (bone salts) Precipitated in Various Media with Applications to Bone Formation. Biol. Bull., XLIV, 280–317, 1923.
The Deposition of Calcium Phosphate and Calcium Carbonate in Bone and in Areas of Calcification. Arch. Surg., X, 983–990, 1925.
39. Wells, H. G.: Calcification and Ossification. Harvey Lectures. Philadelphia, Lippincott, VI, 102–146, 1910–1911; Also: Arch. Int. Med., VII, 721–753, 1911. Chemical Pathology. 5 ed. Philadelphia, W. B. Saunders Co., 790 pp., 1925.
40. Wills, Lucy: Blood Calcium and Inorganic Phosphates in Children with Marked Lack of Muscle Tone. Brit. Med. J., I, 302–304, 1925.

THE SIGNIFICANCE OF THE ACCESSORY TARSAL SCAPHOID*

BY ISADORE ZADEK, M.D., NEW YORK CITY

Supernumerary bones about the foot are very common. Among those best known and occurring with the greatest frequency are:

1. *Os trigonum*,which is placed close to the posterior superior border of the astragalus.

2. *Os peroneum*, which is located just posterior to the base of the fifth metatarsal bone and underneath the cuboid.

3. *Os vesalianum*, which is in close contact with the inferior lateral border of the base of the fifth metatarsal and follows closely the outline of the main bone.

4. *Accessory scaphoid*, which is also known as os tibiale or os tibiale externum, though the latter two terms are undesirable. It would seem best to differentiate these two conditions.

Our knowledge of the existence of these various bones has not been recently acquired. Their presence was known long before the use of the roentgen ray, which, however, has added interest to the subject and has shown how frequently they occur. It is astonishing to realize how much information the earlier anatomists had of these small bones. Knowledge of them dates back to the sixteenth century with the report of Vesalius.

Some of these supernumerary bones are true sesamoids and others do not occur in tendons.

As an illustration of the great frequency of these supernumerary bones, Geist in 1914 reported their occurrence in thirty out of one hundred persons between ten and sixty-four years of age, who had never had any foot trouble whatever. This report was an x-ray study, an antero-posterior and lateral radiograph being made of each foot. Forty-six of the subjects were male and fifty-four were female. Geist found the os tibiale externum present in fourteen of these one hundred individuals. It occurred unilaterally nine times and bilaterally five times.

The greatest importance attaches to the presence of these extra bones because inexperience in reading radiographs sometimes results in an interpretation of fracture where no fracture exists. This is not likely to occur in the case of the os peroneal or the ordinary os tibiale, because these bones cast an oval shadow and there is a space between them and the neighboring large bone.

Indeed the appearance of the actual bone itself on dissection may closely simulate a fracture. So strong is the resemblance that the bone known as the os trigonum was considered a fracture by Francis T. Shepherd,

* Read before the Orthopaedic Section of the Academy of Medicine.

FIG. 1
From Dwight, showing position of the accessory tarsal scaphoid.

from his findings in the dissecting room in 1883. This has been described as Shepherd's fracture.

The os vesalianum casts a shadow which in the x-ray appears as though a flake of bone had been pulled from the posterior lateral tip of the fifth metatarsal.

The accessory scaphoid casts a shadow which has all the appearance of a fracture of the tubercle of the scaphoid with slight displacement. This shadow might, without great difficulty, be falsely interpreted as a fracture. Indeed, in 1913 Horwitz published a paper entitled "Uncomplicated Fractures of the Tarsal Scaphoid." These patients had frequently "forgotten" the original injury and sought relief for a "weak ankle." This weak ankle he ascribed to a tearing off of the portion of the tibialis posticus, which inserted into the scaphoid. This allowed the overacting peroneal muscles to pull the foot into a valgus position. He stated that these patients showed tenderness over the scaphoid,—a position not sensitive to pressure in ordinary weak foot. This conclusion is obviously an error, as this is one of the commonest localities for sensitiveness in ordinary weak foot. His x-ray prints confirm the fact that he was dealing with supernumerary bones, chiefly the accessory scaphoid.

The interest of the author in this condition is different from that of any of the above reports and, to his knowledge, the importance of the accessory scaphoid from this angle has not been recognized before.

A few months ago, a girl, eleven years old, was seen who had apparently unusually prominent scaphoids, associated with flat feet. X-rays demonstrated the presence of large accessory scaphoids and it was decided to remove them. At operation a most unusual condition was encountered. The tendon of the tibialis posticus was found entirely inserted into the scaphoid and it did not extend beyond this bone. The tendon of the tibialis posticus was incised in the direction of the fibres at its insertion,

and, by careful dissection, a line of cleavage was found between the accessory scaphoid and the scaphoid proper. This accessory scaphoid was found completely enclosed in the conical expansion of the tibialis posticus tendon.

According to previous reports, of which the Clinical Atlas by Dwight may be taken as an example, it is stated that this bone is never completely covered by the posticus tendon. Grossly there was smooth bone at the line of contact but no hyaline cartilage. The contour of the surface was somewhat wavy and the surface of the one closely followed that of the other in its undulations, so that they interlocked. There was obviously no movement at this area of contact and movement could only be demonstrated when the line of separation was artificially made over a considerable part of the contact. In order to remove this accessory scaphoid it was necessary to sever the tendon of the tibialis posticus for about three-fourths of its insertion. A portion of the scaphoid itself still projected. This was removed by means of an osteotome and mallet, the bone smoothed with a rasp, and the tendon of the tibialis posticus united. Through this same incision an astragaloscaphoid arthrodesis was performed. After closing the incision, plaster-of-Paris bandages were applied, extending from the top of the calf to the toes, with the heel inverted and the forefoot down, with the foot at a right angle. Recovery was uneventful; subsequently the patient was fitted with Whitman braces, but even without them she maintains excellent foot balance without effort.

As a corollary to the above observation, it seemed likely that one might suspect the presence of an accessory scaphoid, if on clinical examination

FIG. 2

N.D., Showing extreme flat feet.

FIG. 3

N.D., X-rays showing accessory tarsal scaphoids.

it were found that the tendon of the tibialis posticus did not pass beyond the scaphoid, associated with a bony prominence in the position of the tubercle of the scaphoid. A number of observations have proved that this is true, these observations being confirmed by the x-ray photograph.

Since this original operation, the author has operated on two other patients and found identical conditions. These patients, as well as a number of others examined but not operated upon, presented the symptoms of ordinary weak foot. These patients included both children and adults. They did not show any greater sensitiveness about the scaphoid than could be properly attributed to their weak feet. In some, local sensitiveness was entirely lacking. The condition has been usually bilateral.

Recently an operation was performed for removal of an accessory tarsal scaphoid where the major portion of the posticus tendon (probably three-fourths) inserted into the scaphoid but some of it continued distally. Normally the tibialis posticus has an insertion into the scaphoid but in these cases it is much more extensive.

FIG. 4

A.F., Showing weak feet and prominent scaphoids.

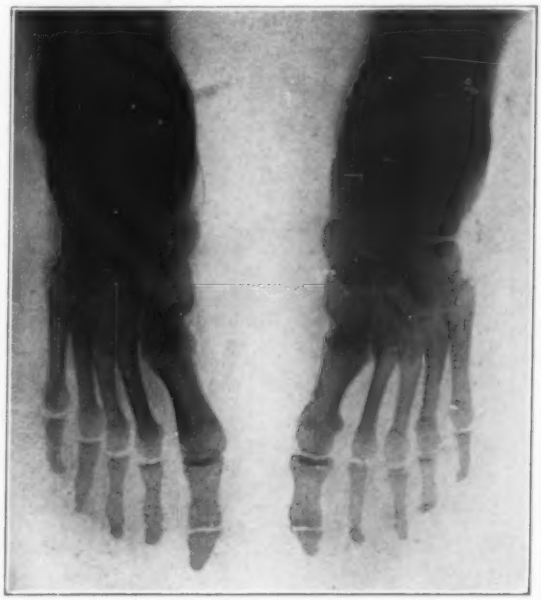

FIG. 5

A.F., Showing accessory tarsal scaphoid on the right.

FIG. 6

E S., Photograph showing termination of major portion of tendon of tibialis posticus in scaphoid.

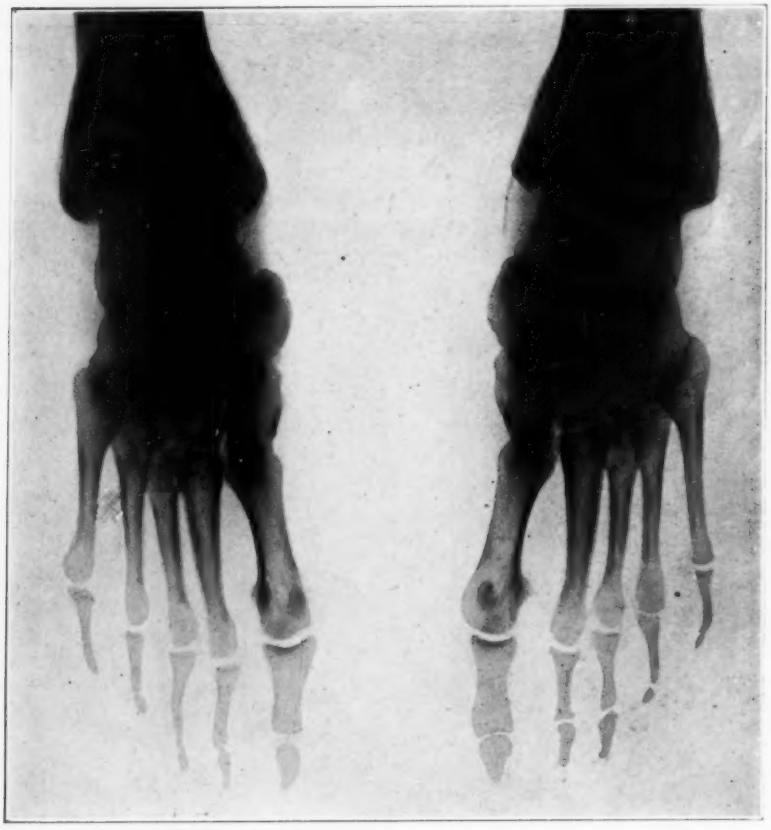

FIG. 7

E.S., X-ray showing accessory tarsal scaphoids.

Experience shows that the course of the tendon of the tibialis posticus can best be demonstrated by having the patient's foot in an attitude of equino varus and having the patient try to increase this attitude against resistance, the resistance being applied by the examiner's thumb at the base of the big toe on the medial aspect.

In several patients it was apparent that the major portion of the posticus tendon ended at the scaphoid but the x-rays were negative for accessory scaphoid. These patients were being treated for weak feet and had responded poorly to proper shoes, exercises and Whitman plates.

We have all had patients with weak feet who have not responded to treatment. In view of the facts above noted, may it not be likely that the condition under consideration accounts for a considerable percentage of our failures?

Therefore, the importance of the accessory tarsal scaphoid lies neither in its presence nor absence *per se*, but in the fact that it is associated with an abnormal insertion of the tendon of the tibialis posticus. It would seem that this abnormal insertion of the tibialis posticus tendon occurs frequently without an accessory scaphoid. The author has not had opportunity to operate upon any of these patients in whom clinical examination showed the major portion of the tendon of the tibialis posticus terminating in the scaphoid but the x-ray negative. The name "weak foot" seems most appropriate for this condition as, mechanically, the foot is inherently weak. Some of these patients seek relief because of the prominent scaphoids and with no additional symptoms.

Just a word about astragaloscaphoid arthrodesis, which has fallen into ill repute with orthopaedic surgeons. The results observed within the past year or eighteen months in the Second Division at the Hospital for Ruptured and Crippled have been uniformly satisfactory. The chief cause for failures has been poor technique in performing the operation. The astragaloscaphoid joint is much more extensive than ordinarily considered, and the operation has been incompletely done. The operation deserves a place in association with other procedures as, for instance, tendon transplantation, in properly selected paralytic valgus cases.

CONCLUSIONS

1. Supernumerary bones about the ankle are of frequent occurrence.
2. Their existence is of considerable medico-legal importance, as they have been mistaken for fractures.
3. The particular importance attaching to the presence of the accessory tarsal scaphoid lies, not in the presence of this accessory bone *per se*, but in the fact that it indicates an abnormal insertion of the tibialis posticus tendon, which produces a "weak foot",—the tendon being entirely or mainly inserted into the scaphoid.
4. No special sensitiveness on pressure is associated with the accessory tarsal scaphoid.

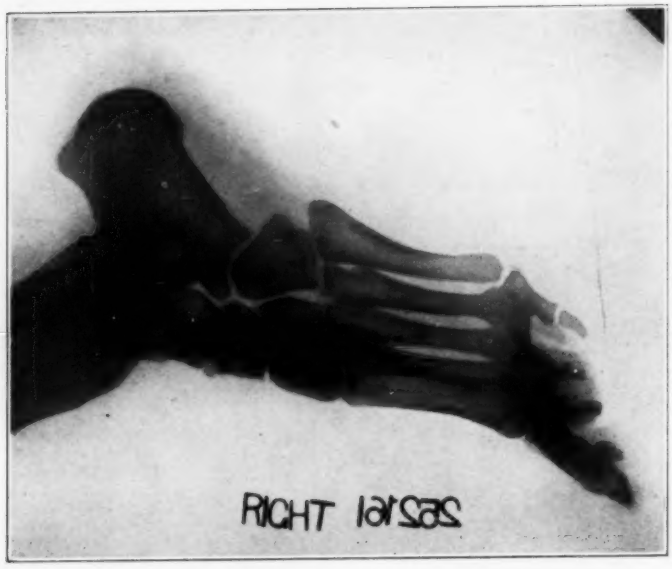

FIG. 9

Ed.S., Lateral view showing accessory tarsal scaphoid and additional supernumerary bone at the superior portion of the astragaloscaphoid joint.

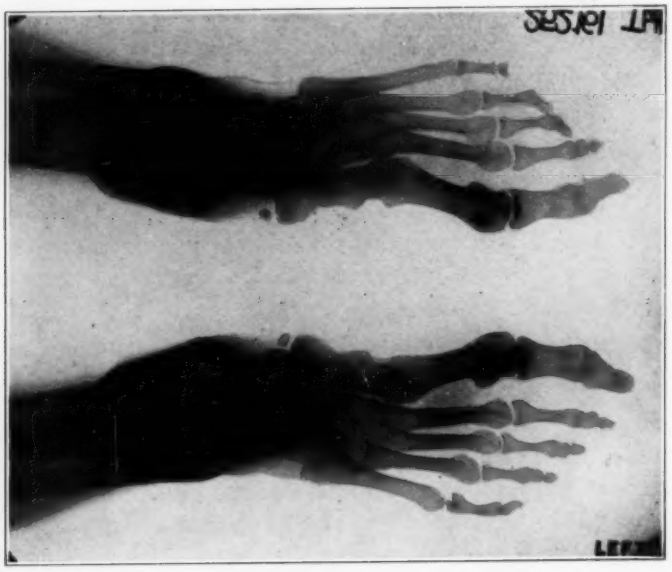

FIG. 8

Ed.S., Showing accessory tarsal scaphoids.

FIG. 10

B.B., Showing flat feet. Patient had worn arches for more than a year Bursae in region of scaphoids are evident.

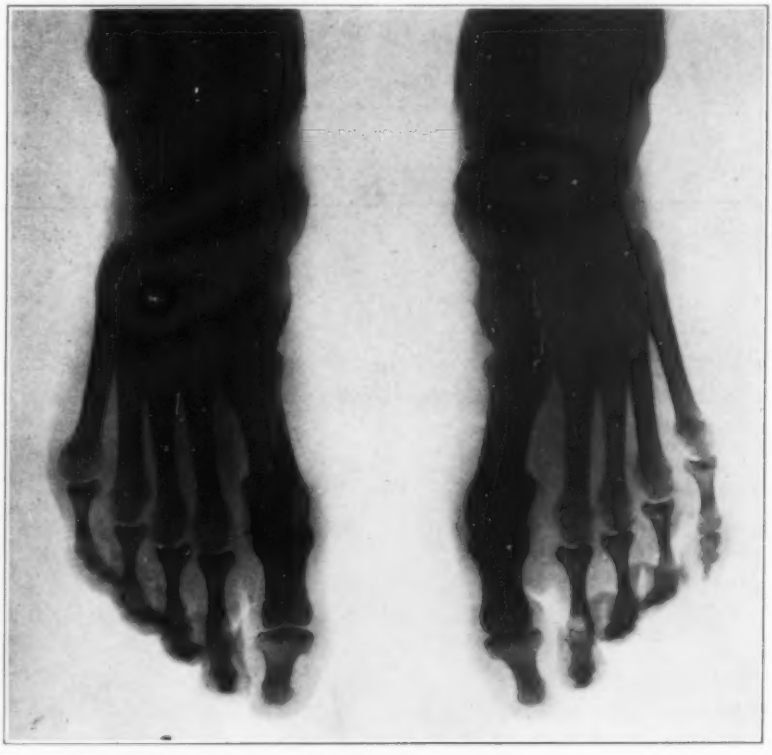

FIG. 11

B.B., Showing accessory tarsal scaphoids.

5. Some of these patients come for examination because of the prominence in the position of the scaphoid without additional symptoms.

6. This condition probably accounts for many of the failures in treating weak feet according to conventional methods.

7. Removal of the accessory scaphoid bone and the prominent portion of the scaphoid is indicated in many cases.

8. Astragaloscaphoid arthrodesis is deserving of another trial with better technique.

I am indebted to Dr. P. W. Roberts, Chief of the Second Division at the Hospital for Ruptured and Crippled, for his interest and the privilege of operating on these patients.

TRANSPLANTATION OF THE FIBULA TO REPLACE BONY DEFECT IN THE SHOULDER JOINT*

BY ROLAND HAMMOND, M.D., PROVIDENCE, R. I.

The transplantation of a bone such as the head and upper part of the fibula to supply loss of bone by accident or disease in such a joint as the shoulder, is by no means an unusual operation. It has been performed probably many times with varying degrees of success; but for some unknown reason, the number of such cases reported in literature is lamentably lacking. A study of the literature reveals but five such cases, one by Rovsing[1], where the upper portion of the fibula was transplanted to supply bony defect in the shoulder joint. He performed this operation in 1910 for a round cell sarcoma of the upper fourth of the humerus in which a pathologic fracture had occurred following an attempt to crank an automobile. Bone grafting was then in its infancy, but the work of Axhausen and of Lexer had proved that such transplantations were feasible. Rovsing believed that the two conditions essential to success were that the transplanted bone should be well covered with periosteum and should have a marrow canal. He had already reached the conclusion that an autogenous graft was most likely to be successful. For these reasons he selected the fibula rather than the tibia, being influenced by the report of a recent case in which a tibial transplant into the humerus had undergone necrosis. After the operation, his patient was able to lift his arm so that he could eat and comb his hair.

Albee[2] reports three cases showing an ingenious treatment of this disability. In addition to transplanting the fibula into the humerus, he has several times dissected out the muscles and attached them to the transplant in their normal positions.

Kirk[3], in reporting the end results of 158 autogenous bone grafts cites one such case, where the upper two thirds of the humerus was resected for a bone tumor, and eleven and one-half inches of the fibula with the head and periosteum was transplanted. The operation was successful, and the patient was able to use the arm, but the malignancy recurred, requiring a shoulder girdle amputation.

Several members of this Association have kindly given me brief reports of five similar operations. One transplantation was similar to the case reported below; one followed a gunshot wound where the upper end of the humerus had been shot away; and in the other three the humerus had been removed because of a pathologic condition such as cyst or sarcoma.

We have learned much about free bone transplantation since Rovsing made his report and it seems wise that the results of such operative

*Read before the American Orthopaedic Association April 27, 1926.

FIG. 1

Fracture of surgical neck of left humerus following attempt to reduce subglenoid dislocation, fourteen weeks after accident.

procedures should be added to the literature, particularly if the case has been followed up over a period of several years.

CASE REPORT

Mrs. E. H., aged 47, a healthy married woman was seen October 13, 1920, with the history that fourteen weeks previously she had fallen and dislocated her left shoulder. Two unsuccessful attempts were made to reduce the dislocation and an x-ray examination had been advised. The x-ray examination had not been made and she had been taking osteopathic treatments without relief. On October 10, 1920, an x-ray examination revealed an old subglenoid dislocation of the left humerus, complicated by fracture of the greater tuberosity. The day before I saw her, an attempt had been made under

FIG. 2

Condition of upper end of humerus following removal of head and previous to transplantation of upper half of fibula to replace loss of humerus.

ether anaesthesia to reduce the dislocation. During the operation the humerus was fractured just below the surgical neck, but the dislocation remained unchanged.

During my examination a reddened, swollen, tender area was observed over the middle of the left clavicle, which was not given the consideration it deserved. As will be seen later, this swelling proved to be the crux of the entire situation.

Reduction of the dislocation by open operation was advised and performed the next day, October 14, 1920. A six-inch vertical incision over the anterior portion of the left shoulder was carried down to the shoulder joint which was opened. The dislocated portion of the humerus was freed up by dissection and was found to consist of three distinct fragments,—that of the head, the greater tuberosity, and the remainder of the upper fragment. There was considerable thickening about the shoulder joint and the glenoid cavity would barely admit the index finger. It was impossible to reduce the three fragments *en masse* and the head and greater tuberosity were removed. The large

remaining fragment was trimmed up and swung into line with the shaft. The tendon of the long head of the biceps was sutured to the deltoid at the upper part of the incision. The incision was closed in layers and a plaster spica applied in horizontal abduction with the elbow at a right angle.

Three days later a slight superficial purulent discharge was seen coming from the upper end of the wound. The wound was opened up and a drain inserted. It was then discovered that the pus came from an abscess over the middle of the left clavicle and easily ran down hill into the shoulder joint. This abscess was located at the site of the swelling found on the day when the patient was first seen, and which had been regarded altogether too lightly.

The vitality of the remaining fragment soon became impaired by the profuse discharge of pus in which it was bathed, and it was removed on October 28, 1920. The discharge gradually lessened and she was able to leave the hospital about six weeks later, December 12, 1920.

The wound continued to show a very slight discharge of pus for several months. On May 10, 1921, x-ray examination showed a sequestrum lying loose in the upper end of the humeral fragment. This was removed May 19, 1921, by a three-inch incision through the old scar and was found to measure one by one and one-eighth inches. One month later the sinus was completely closed and has remained so ever since.

The arm gradually recovered strength and range of active movements, but some pain was experienced with any active use. There was but slight increase in power of abduction during the succeeding two years. Bone transplantation was considered at this time. During this period the upper end of the humeral fragment, as shown in repeated x-ray examinations, gradually assumed a globular shape with a tongue of bone projecting up toward the glenoid cavity. For these two years she could dress and feed herself and do much of her housework, but gained no further use of the arm. There was no power and no leverage in the upper arm, and she depended entirely on her forearm and elbow for both strength and leverage.

Early in 1924,—three and one-half years after the first operation—the patient began to notice more pain, associated with crepitus, in attempting to use the arm. The condition was becoming unbearable and a transplantation of the upper end of the fibula into the upper part of the humeral fragment was advised. At my request, the patient consulted Dr. E. G. Brackett, who concurred in the opinion that this transplantation be performed. She was examined by an internist and found to be a good surgical risk. Two months of deep massage and manipulation were given in order to stir up any evidences of deep seated infection remaining in the wound, but no symptoms resulted and the tissues were considered to be in a healthy condition.

The operation was carefully planned and two operating teams were organized: one to remove the fibular graft, the other to prepare the shoulder and humerus to receive the graft. The operation was performed May 22, 1924, after a three day preparation of the skin.

Shoulder Region: by the writer assisted by Dr. Herbert E. Harris. The original incision was opened up and dissection carried down to the old bed of the humerus. The irregular mass of proliferated bone at the upper end of the shaft was removed and the anterior half of the shaft for a distance of four inches bivalved and removed to expose the marrow cavity. The glenoid cavity was dissected free of fibrous tissue to receive the head of the fibula.

Leg Region: by Drs. Robert C. Robinson and John Champlin, Jr. A nine-inch vertical incision was made from above the head of the left fibula to the junction of the middle and lower thirds of the shaft. The anterior and posterior muscle planes were separated from above downwards until the fibula was reached at the middle and lower thirds. The length of the transplant was determined by measurements and the fibula sawn across at the proper level. The lower end of the upper fragment was isolated and the muscles and intermuscular septum separated from below upward to the head. The

FIG. 3

Condition of transplant one year after operation.

external peroneal nerve was then identified, the surrounding fibrous tissue and ligaments of the upper tibio-fibular articulation were separated and retracted forward *en masse*. The upper part of the fibula to be removed was then abducted from its bed, and the upper end completely disarticulated, leaving the attachments of the biceps tendon intact with the joint ligaments. A portion of the biceps insertion was sutured to the edge of the calf muscles. The deep layers were sutured with plain gut and the skin with silk and a ham splint applied. This dissection was so carefully performed that the resulting nerve involvement was very slight and the paraesthesia lasted but a few weeks. A small tongue at the lower end of the fibula was shaped so that it would fit into the medullary cavity of the humerus.

The graft was now transferred to the arm incision, the tongue on the lower part fitted into the medullary cavity of the humerus, and sprung into position by leverage. The fit was accurate and secure, but the graft was anchored by three sutures of kangaroo tendon passed through drill holes in the humerus. The arm wound was sutured with plain gut in the deep layers and silk in the skin, and a small drain inserted and removed

FIG. 4

Condition of transplant two years after operation with elbow supported.

forty-eight hours later. A plaster spica was applied with the arm in horizontal, forward abduction which position seemed to hold the head of the fibula into the shoulder joint without danger of its slipping out.

The convalescence was stormy, with marked nausea and vomiting, air hunger, increase of blood urea and nitrogen and signs of kidney irritation. In a week she was out of danger and in a month out of bed. Both wounds healed by first intention. She left the hospital able to walk, at the end of seven weeks.

Three months after the operation (August 12, 1924) the plaster spica was removed but no union was present. The x-ray examination showed the graft to be in good position. Another spica was applied with the arm in the same position of abduction.

On November 4, 1924, six months after the operation, the spica was removed, union found fairly firm and coaptation splints, shoulder cap, swathe and sling applied. One week later she was given ultraviolet therapy from an air cooled lamp and light massage, and this treatment, with graduated gymnastic exercises, was continued for about four

FIG. 5

Amount of abduction present one year after operation.

FIG. 6

Elevation of arm possible one year after operation.

FIG. 7

Ability to put arm behind back one year after operation.

months. During this time there was gradual continuous improvement in strength and range of motion, and the deltoid began to fill out.

On August 4, 1925, she reported that after a long automobile ride which she had taken with the left elbow resting on the arm rest of the rear seat, she felt a sudden increase of pain in the shoulder and inability to raise the arm. Examination showed some muscular spasm, crepitus and pain on motion. X-ray examination showed some increased radiability of the fibular transplant and a transverse line near the upper part of the bone suggestive of a minute fracture. The arm was placed in a sling and in three weeks was restored to its previous condition.

Since this time there have been no unusual manifestations. During the past year there has been no noticeable improvement in the use of the arm, except that the deltoid has increased slightly in size. Probably there will be no further improvement, and apparently she has obtained all the benefit which may be expected from the operation. The leg functions perfectly.

Successive x-ray examinations have shown several changes in the upper part of the transplant. It has widened and become slightly globular. The radiability of the bone has increased and several minute pieces of bone lying loose around the head are to be seen in the later films. The lower end of the transplant remains firmly united to the humeral shaft. There is marked laxity of the shoulder which allows the upper part of the transplant to drop down nearly out of the glenoid cavity when the arm is hanging at the side. When the elbow is supported (Fig. 4) the transplant occupies its proper place in the joint cavity.

Although the operation has not been as successful as was to be hoped, it has given her the ability to raise her arm to her mouth and to the top of her head, and has relieved her of pain which had been constant during the three and a half years preceding the transplantation.

REFERENCES

1. Rovsing, T.: Erfaringer og Overvejelser over Lungekirurgi, Hospitalstidende, Kobenh., LIII, 436–440, 1910.
2. Albee, F. H.: Restoration of Shoulder Function in Cases of Loss of Head and Upper Portion of Humerus, Surg., Gynec. and Obst., XXXII, 1–19, 1921.
3. Kirk, T. N.: End Results of 158 Consecutive Autogenous Bone Grafts for Non-union in Long Bones. J. Bone & Joint Surg., VI, 760–799, 1924.

DISCUSSION

Dr. A. Bruce Gill, Philadelphia, Pa.: I wish to show several lantern slides of a case in which I transplanted the upper end of the fibula to replace the upper end of the humerus. This case has recently been reported in full before the Philadelphia Academy of Surgery. In 1921 the patient suffered a comminuted fracture of the upper end of his humerus. The surgeon in charge of him finally excised the upper end of the humerus. I saw him a year later at which time he had a flail shoulder and was unable to work at his trade as a bricklayer. In February of 1922, operation was performed transplanting about four inches of the upper end of the fibula, including the head, to replace the head and upper end of the humerus. Dissection was made at the shoulder joint in order to put the head of the fibula in contact with the glenoid and the acromion. The end of the fibula was implanted into the medullary canal of the humerus. The arm was dressed in abduction in plaster cast. The transplant healed in well. Five months later patient fractured it in an accident with a street car. The fracture of the transplant healed promptly and recovery was uninterrupted. In April of 1923, patient returned to his occupation at which he has worked ever since. X-rays made within the past month show the fibula has increased in size so that its diameter is almost equal to the diameter of the humerus. The head of the fibula is in contact with the glenoid and the under portion of the acromion. Patient has

active abduction to about seventy degrees. There is passive abduction to about a hundred and ten degrees. Rotation is good. Patient is able to do with his arm everything necessary in following his occupation and leading a normal life. He says that he frequently engages in fights and is able to maintain a suitable offense and defense.

NOTE: Dr. Robert McE. Schauffler, Kansas City, Mo., also participated in the discussion of Dr. Hammond's paper, presenting a report of a similar case. A complete report of his case will appear in the next issue of the *Journal.—Editor.*

TUBERCULOSIS OF THE HIP IN CHILDREN*

A Review of Terminal Results at Canton

BY LEMUEL D. SMITH, M.D., MILWAUKEE, WISCONSIN

At the time of the examination there were twenty-eight children at the Massachusetts Hospital School at Canton, Massachusetts, who had been sent there with the diagnosis of tuberculosis of the hip, after having been treated for different periods of time by various methods. The accuracy of the diagnosis in many of these cases will probably be questioned, particularly two in which full motion obtains and in which no destruction has taken place in or about the joint. Another case, diagnosed as tuberculosis of the hip and treated as such until admission to Canton, where a low Pott's disease was discovered without any involvement of the hip joint, is included; not to show the possibility of mistaking a low Pott's disease for hip disease, but to show the result of immobilizing a sound hip. An attempt has been made to classify results with reference to early treatment during the acute stage as well as to study the method pursued at Canton. The list is not large and the averages of results are not conclusive, but certain of the tables are suggestive. The table under Atrophy seems to be illuminating.

In a majority of the cases the essential joint structure has been destroyed, function has been lost, shortening has occurred and deformity obtains. From the standpoint of the joint alone, the result does not appear satisfactory.

However, it was only quite recently that "hip-disease" was but a small part of the general picture that usually accompanied it: pale, weak unfortunates progressing to amyloid degeneration, meningitis, miliary tuberculosis and finally a merciful death. These patients are, without exception, sun browned, well nourished, active, vigorous, happy children going to school (out-of-door school), indulging in all the sports and pastimes of their age. Here is not a condition "most melancholy to see, most miserable to endure". Their condition of vigor and general health seems to be better than the average normal child. Of their particular infirmity they do not appear to be much aware. They are doing all the things all children of their age are doing and having a lot of fun at it. Compared to children with this disease a few years ago their condition is a brilliant achievement.

*Studies made during Post-Graduate Course in Orthopaedic Surgery, Harvard Medical School, Boston Children's Hospital and Massachusetts General Hospital, Boston, Mass. These studies were carried out at the Massachusetts State Hospital School at Canton, Mass., through the kindness of Dr. John E. Fish, Superintendent.

TREATMENT

An intensified hygienic regime is practiced without special emphasis on any one measure except, perhaps, fresh air. The active cases are given bed traction until the acute symptoms of pain and muscle spasm subside, which seems to occur in a remarkably short time. The patient is then fitted with a Bradford abduction traction splint. He becomes ambulatory and engages in the normal activities of a child of his age.

All wards have the "monitor system" of ventilation which depends upon the gravitational movement of air, as exemplified by the Indian tepee with its open top. Demonstrations with small models of buildings appear to establish its superiority over a blower or forced draught system in effecting change of air.

The location is inland, a few miles from the seashore and about two hundred feet elevation.

These children are out of doors during all their wakeful hours. The school classes are taught in the open air in all but the most inclement weather. The children are thus exposed to all the sunshine available, but no special emphasis is given to it as at Leysin and Perrysburg. They are clothed and only parts of their bodies are tanned, but a very real tan this is. So heliotherapy, while not stressed, would seem to play an active part in this program, for, of course, any open-air treatment must be sunlight treatment as well. It is not necessary to be in the sun's direct rays to receive its virtue. Light diffuses, more especially the ultra-violet portion, to such an extent that at certain times the diffused light is richer than the direct in therapeutic rays,[1] so long as they are not filtered out by window glass. Nor is it necessary for the sun to shine, in the accepted meaning of the term, for cloudy days may be more rich in ultra-violet rays than certain bright ones. So here, as at the open-air hospitals at Baschurch, Heswell, etc., the excellent results would appear to be the issue of a combination of favorable conditions, not the least of which is sunshine. And in this list of favorable conditions must be placed that intangible essential, so hard to describe but so really apparent, that happy, optimistic spirit of cooperation and sense of well-being and fitness of things that some persons are so successful in instilling into groups over whom they preside. The leaven of wise, firm, gentle, inspiring leadership is manifest here.

RESULTS

Useful Joints. Six of the twenty-seven cases (22%), show articular surfaces likely to be useful as true joint surfaces. In the acute stage four of these had been immobilized in plaster spica, one with Bradford abduction splint, and one with no fixation or apparatus.

Ankylosis. In twenty-one cases (78%), ankylosis is either present or confidently expected. The treatment of these cases in the acute stage was:

Plaster spica	10 cases	37.6%
Bed Traction	5 cases	23.8%
Bradford Splint	2 cases	9.5%
Arthrodesed	2 cases	9.5%
No apparatus	3 cases	9.5%

Abscess. Abscess occurred in ten cases (40%), in each of which ankylosis obtains or is expected. Seven of these opened spontaneously, two were incised and drained. In one the abscess absorbed without drainage. Eight progressed to early bony ankylosis.

Early Treatment (Before admission to Canton)

Plaster spica	14 cases	4 retain functional joints	28%
		10 are ankylosed	72%
Bradford abduction	4 cases	2 retain functional joints	50%
		2 are ankylosed	50%
Bed Traction	2 cases	2 are ankylosed	100%
Arthrodesed	2 cases	2 are ankylosed	100%
No apparatus	2 cases	2 are ankylosed	100%

Atrophy

No fixation or apparatus	3 cases	average shortening	.75 inches.
Bradford abduction splint	3 cases	average shortening	1.16 inches.
Bed traction	5 cases	average shortening	1.20 inches.
Plaster spica	15 cases	average shortening	1.54 inches.
Arthrodesed	2 cases	average shortening	1.75 inches.

Atrophy is probably more apparent in these cases because it is accentuated by comparison with the opposite leg, hyperdeveloped by the increased work thrown on it in compensation by the very active life led by these children. It has been pointed out by Legg[2] and later by Allison and Brooks,[3] that atrophy is not incidental to the disease but to disuse. This is well shown in one of the cases, in which a nondiseased hip was immobilized and treated for tuberculosis. On admission to Canton the lesion was discovered to be in the lumbar spine. This leg shows one inch shortening and marked thigh atrophy. It is the contrast with the other excellent results of this regime, the vigorous abounding health and well nourished bodies of these children and the excellent response of the joint lesion itself, that stresses what a few years ago would have been held of minor relative importance, i. e., this disparity in length and circumference of legs, which is not a part of the disease, but incidental to treatment.

Thigh Flexion. Lateral Deviation of the Spine. In all but the six cases retaining functional joints there is a marked permanent flexion with usually a marked permanent abduction or adduction which has obtained for several years, causing compensatory lordosis and lateral deviation. In no case does any of these functional compensations fail to over-correct: that is, there is no fixed deformity. No case of spinal deviation shows any tendency to structural change. This may, indeed, come later, but its failure to appear at a very formative period following, in many cases, several years of marked lordosis and lateral deviation raises the question

of the prime importance of posture in the etiology of structural scoliosis and lordosis.

Gait. It was observed that only those having permanent abduction had an ungraceful gait. This abduction gait is very characteristic and unmistakable and accompanies any degree of permanent abduction. An angle as small as five degrees will show it. It is characterized by a shoulder throw or lurch to the abducted side when the weight is placed on that thigh, in response to the necessity of getting the abducted leg under the center of gravity of the body. In this respect two girls, nearly of the same age are in marked contrast. One had a permanent flexion of eighty degrees and permanent adduction of forty-five degrees. Her gait was a gliding, graceful movement without any unsightly sailorman's swagger of the shoulder. The other had forty-five degrees permanent flexion and twelve degrees abduction. The gait was characteristic, clumsy and ungraceful. It would appear that the optimum position for an ankylosed hip, for sitting and walking, is flexion from fifteen degrees to twenty-three degrees with neutral to slight adduction, and not abduction.

CONCLUSIONS

The regime at Canton maintains the vitality of the patient at the highest possible level. To this end the treatment is constitutional rather than local. The diseased hip is protected from weight-bearing but not from motion with a Bradford abduction traction splint. General freedom of activity is encouraged as soon as the symptoms of acute spasm and pain subside.

The condition of the diseased hip corresponds very closely to the general condition.

In all cases where ankylosis is now present or expected the disease was well advanced and destruction was marked before admission to Canton.

In all cases progress of the disease was promptly arrested when placed under this regime.

The results attest the importance and the virtue of a nice balance of all hygienic measures without stressing any particular agent. It seems to prove that the therapy of the sun is potent at our latitudes, under conditions where its ultra-violet rays are usually weakest, i. e., at low altitude, inland from the seashore.

Twenty-two per cent. of all the cases have come through with articular surfaces likely to be useful as true joint surfaces. Findings at Canton seem to indicate that this proportion would be markedly larger should the patient be placed under this regime at the incipiency of the joint lesion. We have no proof that these were tuberculous lesions of the joint but the clinical signs and symptoms had led to this diagnosis.

Atrophy seems proportional to degree of disuse and not to the virulence of the disease.

The relation of posture to structural scoliosis does not appear to be

intimate. All but those retaining functional joints present a marked and some an extreme compensatory scoliosis and lordosis. In none of these cases has any appreciable structural change taken place in the spine.

The increased effective length of an abducted thigh is without advantage in view of the lurching, ungraceful gait incidental to it and abduction is to be avoided.

I wish to thank Dr. E. H. Bradford and Dr. John E. Fish for their kindly cooperation in making possible this review and Dr. Robert B. Osgood and Dr. Nathaniel Allison for their helpful suggestions.

CASE HISTORIES

FIG. 1

CASE R. L. Girl born in 1910. Father has phthisis. Onset at four years of age. Received hospital treatment for one year which consisted of recumbency in plaster spica.

Was admitted to M. H. S. in June, 1915. There was one inch atrophy of thigh and one inch atrophy of calf, no shortening. There was some motion present. Some muscle spasm persisted. She became ambulatory in a Bradford abduction traction splint.

Her present condition is excellent. She stands with extreme lumbar lordosis and marked deviation which over-corrects. Her gait is an undulatory glide, but not ungraceful and with no shoulder lurch. There is 80 degrees permanent flexion, 45 degrees adduction, 45 degrees internal rotation, 4½ inches shortening, 3¼ inches atrophy of the thigh and 1¼ inches atrophy of the calf. The joint is rigid (Fig. 1).

FIG. 2

CASE M. K. Girl born June, 1918. Onset at two years of age following injury from a fall. Diagnosed as tuberculosis and treated as such in one of the large hospitals in Boston with plaster spica for three years and at seaside hospital during the summers.

Admitted to M. H. S. September, 1923, with no shortening, 20 degrees permanent flexion and 5 degrees abduction, no motion elicited. There was sensitiveness about the joint and some muscle spasm. The spica was removed and bed traction instituted for four months, when active symptoms had disappeared and she became ambulatory in a Bradford abduction traction splint (Fig. 2).

Present condition is excellent. Posture is normal, gait free in splint. There is no atrophy nor shortening. There is about 10 degrees permanent flexion with 60 degrees motion in flexion, 10 degrees motion in abduction and no motion in rotation.

CASE N. N. Boy born in 1910. Onset at seven and one-half years of age, with complaint of pain in the left hip. An abscess in the buttock was incised and drained. Patient was then taken to another hospital and treated with plaster spica for six months.

Admitted to M. H. S. January, 1918. There was one-half inch shortening, slight atrophy of soft tissues and limitation of motion in left hip. Examination showed marked kyphos at the fourth lumbar vertebra and two draining sinuses in fold of the left buttock. He was placed on a Bradford frame. Two months later he was given plaster jacket and became ambulatory.

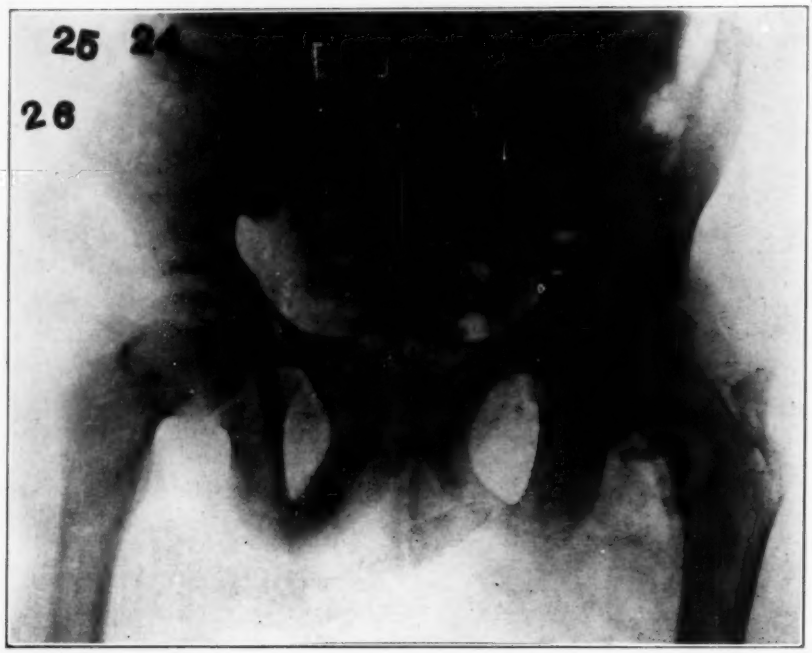

FIG. 3

His present condition is excellent. There is marked kyphos over the fourth lumbar vertebra, with a draining sinus on each hip. He is now wearing a Taylor back brace. There is 20 degrees permanent thigh flexion, 15 degrees internal rotation, 15 degrees motion in flexion, 10 degrees motion in rotation, no motion in abduction or adduction, 1¼ inches shortening, 1¾ inches atrophy of thigh, and 1½ inches atrophy of calf.

This case shows either a remarkable demonstration of recovery from hip disease, or marked atrophy from disuse only (Fig.3).

REFERENCES

1. ROSSELET, A.: Heliotherapy A. Rollier. Oxford Medical Publications.
2. LEGG, A. T.: The Cause of Atrophy in Joint Disease. Am. J. Orthop. Surg., VI, 84–90, August, 1908.
3. ALLISON, N. AND BROOKS B.: Bone Atrophy, A Clinical Study of the Changes in Bone which Result from Non-use. Arch. Surg. V, 499–526, 1922.

PAGET'S DISEASE

BY HERMAN B. PHILIPS, M.D., NEW YORK CITY

The subject of Paget's disease is fascinating from several view points, the most prominent of which is the bizarre but fairly constant character of the symptom complex. The anatomical variations are so constant in the typical and average case, that the condition may be readily recognized by undergraduates and even laymen. Several hundred case reports are easily found in the literature and nothing additional can be added to the description of the symptoms or etiology, but some observations of a slightly new character, the results of thorough roentgenological studies, impel me to report some unusual features in a series of fifty cases, personally observed.

For a description of the gross findings of Paget's disease, nothing is quite as comprehensive as Paget's[4] original article and the clearness and completeness of his report has never been improved upon. For further general information, the reader is referred to the works of other authors, listed in the bibliography.

It is conceded that Paget's disease manifests itself roentgenologically in definite characteristic ways. The roentgenological appearance of the skull is so unique and characteristic, that for many years it has been the basis of clinical judgment in making a diagnosis of this condition. Of late numerous reports have appeared in the literature of isolated affections of other bones of the skeleton and reports of so-called "monosteitic" Paget's disease have appeared. Notable among these are: Beclere[5] who reports one case in which the metacarpals and phalanges were involved; Goldthwait, Painter, and Osgood[6] who described a similar case (quoted by Carman and Garrick[7]) and who also included a case observed by them with involvement of the metacarpals; S. Moore[8] who reported monosteitic involvement of the third lumbar vertebra; Shuller[9] who reported one case with temporal bone involvement with ear symptoms.

To this group the author can add three cases: one of the tibia, one of the right innominate bone adjoining the acetabulum (Illustration I) and a third case, observed abroad a few years ago but not studied personally by the author, of involvement of the sphenoid bone. It is unquestionable that if routine careful roentgenological studies of the entire skeleton were made in all cases of proven or suspected Paget's disease, the results would indicate far greater involvement than noted in previous studies and reports. Carman and Garrick[7] state that if the patients were systematically examined with the x-rays it is probable that other bones would be found frequently to be involved, except in very early stages of the disease. Bartlett[10] reports a case where roentgenologically and physically the skull only was involved, but autopsy revealed early involvement of the femur. Similar experiences were recorded by Koch[11]. Routine complete roentgenological studies of

FIG. 1

"Monosteitic" Paget's disease, involving adjoining portions of right pubes and ischium. Slight elevation of cortex is present, with definite striations.

the entire skeleton would also serve beyond question to vary the present conception of relative incidence of bones involved. It has been the experience of the author that in a good many instances characteristic involvement of the pelvis can be demonstrated when the skull is entirely normal, and it has been the routine to always include roentgenograms of the pelvis and skull when any of the long bones present suggestive signs of Paget's disease.

Roentgenologically, Paget's disease manifests itself in the skull by the presence of knobby-like masses of bone lying between and in the inner and outer tables and sometimes involving the outer table alone. These changes produce a marked thickening and enlargement of the cranial bones. Encroachment on the inner table is very rarely seen, and pressure effects from encroachment on the inner table of the brain, have not been described. Pressure effects, however, at the cranial foramina, have been reported along with the accompanying neuritic disturbances. In the long bones the characteristic appearance is one of striations or linear trabeculations of increased density alternating with others of decreased density. Linear trabeculations are constantly found in this disease. The striations run, as a rule, longitudinally and, usually, roughly parallel to each other. Occasional bony protuberances with broad bases are observed in the long bones, the cortex still presenting the characteristic "combed out" or striated appearance, irregular, however, in these elevated lesions. Small and large cystic areas or areas of bone absorption or rarefaction are seen in the long

FIG. 2

Paget's disease with general osteolytic area involving left frontal and fronto-parietal regions. Arrow indicates focus of the development of osteogenic sarcoma, after six months observation of apparent quiescent condition.

FIG. 3

Irregular calcification of meninges and falx cerebri, simulating Paget's disease.

FIG. 4

Gummata and osteoperiostitis with generalized moderate increased thickness of skull bones originally mistaken for Paget's disease.

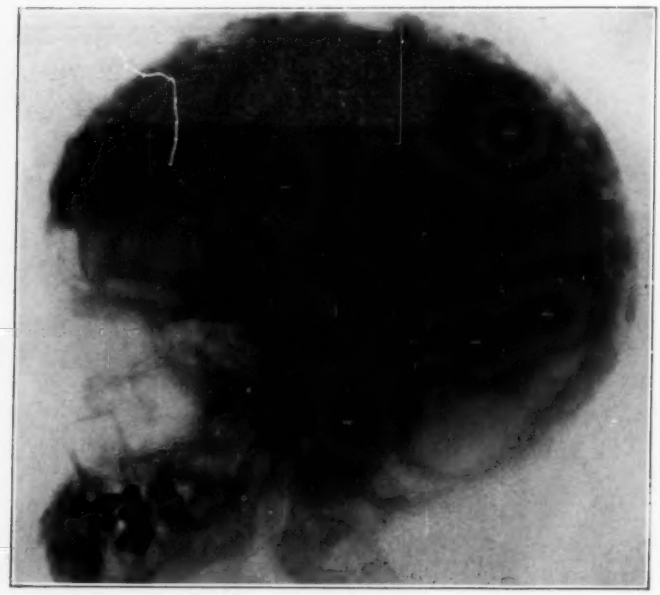

FIG. 5

Typical Paget's disease of the skull with pronounced enlargement of cranium. In one instance a teleoroentgenogram of the skull showed the anteroposterior diameter to be 9 inches and the transverse diameter 7 inches.

FIG. 6

Various types of Paget's disease of the long bones. (See text.)

bones as well as in the skull. However, rarefaction is not a common roentgenological finding in this condition. Bowing deformities in the long bones and occasionally in the pelvis are so constant in this condition as to be of decided value in differential diagnosis.

As regards the incidence of spontaneous fractures, it has been stated even by Paget in his original article that spontaneous fractures are infrequent. The author has seen six spontaneous fractures in Paget's disease: three of them were identical fractures in the same location, in the lesser trochanteric portion of the femur, one of the neck of the femur, and two in the upper end of the humerus. This represents an incidence of twelve per cent. LeWald[12], in his study of fourteen cases, encountered four in which spontaneous fractures had occurred.

A few cases in my series deserve special comment. One was the occurrence of a pronounced and generalized Paget's disease in a boy of sixteen. He also presented the unusual characteristic of fascial bone involvement, with marked enlargement of his left superior maxilla. This has been considered a rare feature of Paget's disease. The same patient presented a spontaneous fracture of his humerus. Paget's disease is not essentially a disease of old age, most of the cases occurring in adult life. Packard, Steele and Kirkbridge[13], include some cases as young as twenty-one years of age.

Another case deserving special comment is one of marked destructive bone changes in the frontal and parietal bones (Illustration II). After a prolonged period of observation there developed an apparent malignancy at the margin of the extensive osteolytic focus. This case was referred to the author by Dr. J. Wishner, for roentgenological studies. He will subsequently make this most interesting case the subject of a special report. Destructive processes in Paget's disease are uncommon and a careful search of the literature reveals only two cases: one of the skull, quite similar in many instances to the case in question, reported by S. Moore[8], and the other reported by Carman and Garrick[7], where marked absorptive processes and coarse trabeculations were present in the left ilium.

Special comment should also be made on the characteristic involvement of the pelvis. When the involvement is early, faint striations are usually seen in the ischium or pubes. Subsequently the ilia become involved. When the disease is still further advanced, marked bowing deformities of the pelvic walls occur with marked protusion of the acetabula into the pelvis, producing the characteristic Otto-Chroback deformity[14]. Frequently the pelvis is involved to such an extent that it is used as a basis for a positive diagnosis of the condition, whereas the skull may show no changes whatsoever. This has been observed in at least six instances in this series.

So much attention has been called to the value of the roentgenological appearance of the skull as an important factor in the differential diagnosis, that it is advisable to elaborate somewhat on possible sources of error. Two cases in mind are quoted. One of them presented irregular calcification

of the falx cerebri and irregular calcification in the membranous envelope of the skull, causing irregular density of the skull in such a fashion as to give it an appearance simulating Paget's disease (Illustration III). Careful stereoscopic studies of the skull served to localize and differentiate these shadows so as to avoid confusion. The second case, which is probably more frequent and may be a source of error, is diffuse gummata and osteoperiostitis of the skull, where multiple foci of bone absorption alternating with foci of productive periostitis, give an appearance somewhat simulating Paget's disease (Illustration IV). Careful study will also demonstrate the absence of increased thickness of the skull bones and the characteristic blotchy deposition of bone found only in Paget's disease.

FIG. 7

Osteitis Fibrosa Cystica. Absence of striations and multiple large confluent cystic areas with generalized atrophy exclude Paget's disease.

CONCLUSIONS

Paget's disease manifests itself with definite roentgenological characteristics permitting a definite diagnosis whether the disease is local or general. The latter part of this statement would probably more truthfully apply by qualifying it as early or late. General roentgenological examinations are advisable in all cases of suspected Paget's disease for the purpose of accumulating data on the relative incidence of bones involved and for

elaboration of diagnostic information. Characteristic changes in the pelvis are frequent and permit of definite diagnosis, in the absence of skull manifestations. This presentation includes a few cases with unusual features.

BIBLIOGRAPHY

1. Butlin: Lancet, 1, Page 519, 1885.
2. Hutchinson, J.: Ill. Med. News, XI, 177, 1889.
3. Stegmann, R.: Diskussion:—Wien. Klin. Wchnschr., XVIII, 619, 1905.
4. Paget, J.: Osteitis Deformans, Medico-Chirurgical Trans. LX, 37–63, Nov. 1 1876.
5. Beclere: Quoted by Carman and Garrick—Roentgenologic Aspects of Osteitis Deformans; Paget's Disease, Report of 15 Cases, J. Radiol., II; 7–28, April, 1921.
6. Goldthwait, J. E., Painter, C. P. and Osgood, R. B.: A Series of Papers Pertaining to Orthopaedic Surgery. Boston, Usher, 1st Series.
7. Carman, R. D., Garrick, W.M.: Roentgenologic Aspects of Osteitis Deformans; Paget's Disease, Report of 15 Cases, J. Radiol., II, 7–28, Apr. 1921.
8. Moore, S.: Observations on Osteitis Deformans. Am. J. Roentgenol. & Rad. Ther., X, 507–518, 1923.
9. Schuller, A.: Roentgen Diagnosis of Disease of the Head, St. Louis, 1918.
10. Bartlett, C. J.: Osteitis Deformans—Report of a Case Showing Gross Involvement of Skull Only, Yale Med. Journal, XVI, 367–378, Mar. 1910.
11. Koch, M.: Verhandlungen der Deutsch Patholog. Gesellsch. 1909.
12. LeWald, L. T.: Roentgen Studies in Bone Pathology, With Specific Reference to Spontaneous Fractures, Including a Report of 14 Cases of Paget's Disease. Miss. Valley Med. Jour., XXIV, 28–29, 1917.
13. Packard, F. A., Steele, J. D. and Kirkbridge, T. S., Jr.: Osteitis Deformans, Am. Journal Med. Sc., CXXII, 552–569, 1901.
14. Pomeranz, M. M.: Osteoarthritic Protrusion of the Acetabulum, A Case Report, Am. J. Surg., XXXIX, 169–170, July, 1925.
15. Alexander, W. G.: Report of A Case of So-Called "Marble Bones", Am. J. Roentgenol. & Rad. Ther., X, 280–301, Apr. 1923.
16. Jack, C. M.: Osteitis Deformans, Am. J. Roentgenol. & Rad. Ther., IX, 626–628, 1922.
17. Lannelongue: Quoted by Jack. Osteitis Deformans, Am. J. Roentgenol. & Rad. Ther., IX, 626–628, 1922.

INTRODUCTORY CONSIDERATIONS IN THE STUDY OF CARTILAGE INJURIES

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With recent developments in the field of traumatic surgery an increasing amount of attention is being given to a study of the injuries of the soft parts. This has led to a desire for more complete knowledge regarding the anatomy, physiology and pathology of these structures. Cartilage is perhaps the one tissue to which the least study has been devoted, except as it is related to the process of bone formation.

The large library of the New York Academy of Medicine does not contain a volume devoted entirely to the subject of cartilage. Much has been written upon injuries to the semi-lunar fibrocartilage of the knee, but these observations are largely of a clinical nature. Even the clinical descriptions are very meagre in other cartilaginous injuries involving such locations as the acromioclavicular joint or the sacro-iliac synchondrosis.

An attempt will therefore be made to gather in this paper such bits of information as appear to have a direct relation to the cartilaginous injuries, and more especially those facts that have a bearing upon the underlying pathology rather than the more extensive clinical observations.

Of what does cartilage chemically consist? How is it formed? Does it repair itself as does bone? How does it react to infection? These are only some of the questions we must ask ourselves before we can come to a true understanding of how it will respond to an injury.

The chemistry of cartilage has been studied by Matthews and others. The nasal septum of the beef was used for most of these studies and the chemists conclude that food finds access to these cells by soaking through an intercellular substance which, strange as it may seem, is secreted or formed by the cells themselves. Boiled cartilage yields chondrin. Chondromucin as seen in cartilage is the same as that found in tendons. Chondro-albumen is very much like osteo-albumen, but not identical with it. Chondroic acid breaks up into glycuronic and sulphuric acid. The exact nature of this process is not known. Chitin is a substance which makes up the ectoderm of the arthropods and is almost identical with cartilage. It is interesting, in passing, that the chemists base upon this fact a theory of evolution, inasmuch as the one is of ectodermal and the other of mesodermal origin. It would seem that a study of the sulphur metabolism might throw light upon the various cartilaginous diseases in view of the fact that sulphuric acid is so intimately concerned in the chemical formation of cartilage. Again we note in many joint conditions a disturbance

of the calcium metabolism, and also the part played by the deposit of purin bodies within the cartilages in gout.

The bearings of the internal secretions should also be mentioned as, for example, in chondrodystrophia fetalis, which MacCallum considers as being primarily a cartilaginous disturbance. The clubbing of the fingers in various conditions is also of interest in this connection.

Before leaving the chemistry of cartilage, attention should be devoted to the synovial fluid which consists of fats, salts, albumins and lymph extractives; also a mucin body called synovin, and still another body closely related to phosphorus. Simmons has found that quantitatively this fluid varies with use. An increase of the albumins and extractives with a diminution of the salts and water has been found as the result of an increased amount of exercise.

We know that cartilage is of mesoblastic origin. Oertel describes a homogeneous metroplasm from which develop the cartilage cells which later become encapsulated. At first they are of a hyaline nature. Matswka found the germinal tissue located within the perichondrium, which Bailey, Schafer and others describe as being composed of two layers, the outer containing the blood supply, and the inner, the chondroblastic cells.

In lower animals a medullary canal may be found passing through the cartilage. Borst and the Italian writers have noted divisions of the cartilage cells themselves. Virchow found that soft connective tissue forms between the cut edges of cartilage in three weeks, but MacCallum is of the opinion that the cells do actually regenerate. In young individuals the cut edges have been found by others to unite without the production of granulation tissue. Ziegler demonstrated the transformation of cartilage into mucoid, alveolar, fibrous tissue and bone. Thiersch noted small islands of cartilage within connective tissue scar formations. Paget showed that following injury, as in the thyroid and costal cartilage, ossification of the cartilage may occur without going through the process of bone production. Klemperer demonstrated the presence of cartilage in tonsillar tissue. As an evidence that the cartilage cells are capable of proliferation, we have, of course, only to observe the development of chondroma.

The early development of cartilage in the embryo has been demonstrated by Miller. His description, however, deals entirely with a staining method.

J. Bland Sutton's extensive and careful work has proven that by retrogression muscles become ligamentous. In lizards a muscle called the femorocaudalis passes between the tibia and fibula and blends with and forms the interarticular cartilages of the knee. The frog has well developed semilunar cartilages, and this comparative study, carried upward to man, leaves little doubt that these structures are a survival of this muscle. The study of the knee joint in the beaver, for example, shows the synovial cavity to be divided into three distinct compartments. In man only a few fibres passing from the midline at the lower part of the patella to be attached to the intercondyloid notch as the ligamenta alaria and mucosa

are the remains of this division. The human fetus at three months shows the bursa behind the quadriceps extensor separated almost completely from the joint. I believe that a distinct and separate band found almost constantly by means of oxygen inflation of the knee is a remnant of this embryonic structure.

The development of the intervertebral disc is most interesting in view of the fact that the pulp originates from the notochord; also that a ligament passing anteriorly and posteriorly to this disc has been found in the fetus, but is later incorporated in the disc itself. The findings of Cunningham are interesting in this same developmental process. A bisection of the axis shows it to contain a lenticular discal cartilage. The ligamentum subflava is also a cartilaginous structure, as, for example, in the fish, and is derived from the intraneural plates and may be of help in understanding the morphological development of these structures.*

In considering the physiology of cartilages we must attempt to understand how this substance lives, and this can probably best be understood by a study of loose bodies as they are found within joints. That they actually live after being detached seems proven by the work of Strangeways. Microscopically he found the surface of such bodies covered with several layers of cells with elongated nuclei, and composed of typical cartilage which showed no signs of degeneration. The nuclei stained well, and he states that proliferation may occur. Well formed giant cells were seen and also stellate cells resembling pre-adipose tissue.

Another proof of cartilage living may, of course, be seen in a study of its transplantation as undertaken by Ziegler, Conklin, Davis, and many others. Murray is of the opinion that such transplanted cartilage, however, is much more apt to undergo early senile changes, but cartilage removed from the nose after transplantation, at the Manhattan Hospital, showed it to be quite unchanged after a period of four years. Work of this nature, of course, is interesting in relation to severe injuries of the nose, ears, etc., and has even been attempted upon the elbow joint. Redfern has noted the difference in the vital power between temporary and permanent cartilage, which does not become developed later into bone.

Bier is of the opinion that any bone particles that may be torn away along with the cartilage, will be absorbed by the synovial fluid. The cartilage then proliferates so as to cover these areas, and in this manner are formed the smooth, round bodies which we see years afterwards.

Granted that cartilage may live within the synovial fluid, we have next to determine how it normally receives its nourishment. This is believed by some to be derived from the synovial membrane, and Redfern has noted that dyes and bile are seen in that portion of cartilage covered by this membrane to a greater extent than elsewhere.

Another theory advanced is that considerable nourishment is carried

*Tonybee has pointed out that the articular synovial membrane in the fetus is continuous over the surface of the cartilage, but this is not seen in the adult.

along the fibrous bands which pass through the cartilage. These bands are in certain types very wavy, and in the intervertebral disc run in an oblique direction so as to form the letter X. The more recent work of Schultze has demonstrated minute delicate canals within the cartilage. The openings of these canals are larger in the portion of the cartilage looking into the joint cavity. No connection of these canals with the general lymphatic circulation has been demonstrated. They seem to originate on opposite sides of the cell, but it is disputed whether they are intercellular or not. From this it would seem that a greater portion of the nourishment is derived from the synovial fluid. The articular cartilages are, of course, partially nourished from the underlying bone. Dr. Wm. G. Clark believes that blood vessels do not exist in human cartilage, but are seen in lower animals, as the dog, for example.

In considering the pathology of this tissue no record of a primary infection arising in a cartilage could be found. However, the part played by the cartilage in tuberculous joint infections may be helpful in understanding how this tissue behaves in the presence of most infections. Goldthwait, Painter and Osgood have noted the infection in hip disease traveling along the glenoid ligament, and lifting the cartilage from the head of the femur. A more detailed microscopic picture is given by Redfern. At the junction of the cartilage with the bone there are numerous minute bony arches through which run the blood vessels and nerves.

In experiments upon dogs, the same author has shown that, following ligation of the costal cartilage, in from three to six days the tissue is converted into a gelatinous mass. In cut cartilages, he notes no change in seven days, but an abundant proliferation in forty-nine days, and perfect fibrous union in twenty-four weeks.

Plummer considers arthritis deformans as a disease beginning primarily in cartilage. Axhausen has produced by means of an electric needle changes that simulate this disease very closely. Wollenberg's theory is that this affection is arteriosclerotic, the underlying bone reverting to cartilage. This requires less nourishment and, therefore, being overnourished, it hypertrophies. Preiser is of the opinion that the disease is due to faulty static relation caused by an uneven pressure within the joint. König has proven it in no way related to gout. From this it would seem that cases of joint injury should be carefully gone into for an evidence of this disease, and careful inquiries should be made into the history of those suffering from this condition, who often come to the surgeon as the result of a recent slight trauma. Rost (cited by Wollenberg) considers that beside an injury there is still another unknown factor responsible for this condition.

Joint-mice were first discovered by Monro in 1726. Poncet and Krageland were able to produce by direct blows upon the knee joint (in the cadaver) small, loose pieces of bone. Budinger on the contrary does not believe they are the result of trauma. Fisher thinks they are formed from a torn capsule, while Rehyer is of the opinion they arise from the joint

cartilage. Baun has advanced the theory that they originate from the synovial membrane which he claims can become cartilaginous in places of abnormal stimulation. That they do not come from synovial membrane which has not been severely traumatized seems quite positive. For example, the author recently removed from the region of the attachment of the semimembranosus, a thin-walled sac the size of an English walnut which was completely filled with these bodies. They were dry, and almost identical with uncooked grains of rice. The patient was a boy, only five years of age, and there is no indication or history that he ever received an injury or any evidence of an infection in any of the joints of his body.

Chondromas, which are most commonly in the hands and feet, but which also spring from a sacro-iliac synchondrosis, the symphysis pubis and other areas, may have a relation to trauma according to MacCallum. These tumors are much more vascular than that of normal cartilage, and they may be transformed into osteoma. Virchow believes they arise from misplaced cartilage cells. Their relation to finger injuries is interesting. Branchioma was described by Lannelonngue as having a relation to the cartilage of Meckels and Reichert. These tumors often became most malignant and should be regarded as such. Bloodgood is of the opinion that the bones to which chondromas are attached should be removed, in order to effect a permanent cure.

The histology of cartilage has already been considerably discussed. It is divided according to the amount of intercellular substance into three main groups: (1) hyaline, (2) elastic, and (3) fibrous. That it does not contain blood vessels, except in the stage of active bone formation, has been quite definitely proven. The articular cartilages are hyaline, except at the acromioclavicular, maxillary and sternoclavicular joints and in the costovertebral articulations. From this it would seem that a careful pathological study, at least in a more recent case, should enable one to determine from whence large loose bodies are derived. This is particularly true in the case of the knee joint where they are often derived from the articular surface of the femur, as described by de Quervain, as well as coming from the intra-articular fibrocartilages themselves.

The histological examination of synovial membrane shows it to be composed of loose connective tissue, the subendothelial cells being held together by an intercellular cement and containing fat in the deeper structures. Also R. J. Terry has described isolated cartilage cells as being found in this region. It is a recognized fact that connective tissue may be easily transformed into bone directly, or that this process may be indirect by passing through the stages of cartilage formation. This phenomenon may be due to circulatory or chemical changes. However, if cartilage cells already exist within the synovial membrane (as in the case of the anterior capsule of the elbow) there does not seem to be any need of considering these more complicated theories in preference to a simple traumatism to account for the proliferation of the existing cartilage cells.

REFERENCES

MATTHEWS, A. P.: Text-Book of Physiological Chemistry. W. Wood & Co., 4th Ed., 1925.

MACCALLUM, W. C: Text-Book of Pathology. Phila. and London, W. B. Saunders, 2nd Ed., 1924.

SIMON, C. E.: Text-Book of Chemistry. Lea Bros. and Co., Phila. and New York, 2nd Ed., 1924.

OERTEL, HORST: Pathology. Paul B. Hoeber, New York, 1st Ed., 1921.

ZIEGLER, E.: Lehrbook Path. Anatomie, 5th Ed., 1887.

SUTTON, J. B.: Ligaments, Their Nature and Morphology. P. Blakeston Son & Co., Phila., 1887.

STRANGEWAYS, T. S. P.: Brit. Med. J., I, 661–663, 1920.

ROST, FRANZ: Book of Pathological Physiology of Surgical Diseases. P. Blakeston Son & Co., Phila., 1923.
(Authorized Translation of S. P. Reismann.)

REDFERN: J. Anat. Physiol., London, XXXII, 96–108, 1897-8.

PLUMMER: Deutsche Akaderine, LXXXIX, 65, 1914.

WOLLENBERG: Zeitschr f. orthop. Chir., I, 24, 1909.

TERRY, R. J.: Anatomy Text-Book. Jackson, P. Blakeston Son & Co., Phila., 8th Ed., p. 256.

AXHAUSEN: Charité Ann. I, 33, 1909.

VACCINE THERAPY AND SEROLOGICAL DIAGNOSIS IN THE ARTHRITIDES*

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Arthritis seems to be the oldest disease of which we have any definite record, as osteoarthritic changes are found in the skeletal remains of the pithecanthropus erectus, a pre-homo sapiens of at least five hundred thousand years ago, a fact which was called to my attention by Mr. Madison Grant. Kramberger has described typical changes of arthritis deformans coupled with caries of the jaw in prehistoric man of the Mousterian period approximately one hundred thousand years back, and he, to my knowledge, was the first to demonstrate co-existent focal infection and arthritis. McCurdy, in "Human Origins," describes caries of the jaw and maxillary abscesses in the skull of the Broken Hill man of Rhodesia, and the Neanderthal man gives evidence of extensive pyorrhea alveolaris. Many skeletons of the Mesozoic period show periosteal changes and productive arthritis. Virchow describes extensive arthritic changes in the bones of prehistoric men, and in skeletons of bears found in the deeper strata of the German forests, so from remote prehistoric times the disease has left its traces as has no other.

Coming down to historic periods, Dr. Eliot Smith found numerous examples of arthritis deformans in the mummies of Egyptians who dwelled along the river banks at a period about 2,800 B.C. In fact he makes the statement that rheumatoid arthritis shows itself in these mummified remains far more frequently than any other disease. It is interesting to note in this connection that the mummies of dwellers in arid regions did not show noticeable arthritic changes. Ewart made the statement that arthritis was certainly as old as civilization, but modern research has shown us that the disease is certainly co-aeval with the advent of man.

The first medical treatise of which I have any knowledge is a papyrus of the fifteenth century B.C., and this deals largely with arthritis. (Translation "Breasted.")

In classical medicine we find frequent allusions to arthritis and podagra in Hippocrates. Galen, and Aretaeus the Cappadocian, of the first and second centuries A.D., laid considerable stress on the disease and the last mentioned author divided arthritis into numerous types according to fixity of process and body location of the disease. He also noted the fact that a joint affection might remain fixed until death, or might wander at will throughout the body. Arthritis at this period was frequently called "morbus articularis," and was mentioned as such by Cato, Lucullus, etc. Orid was afflicted with it, and Lucian of Saramosta wrote a comedy on the

* Presented at the meeting of the American Orthopaedic Association at Atlanta, April 28, 1926.

disease called "Trago Podagra." Even in those days arthritics were a burden to the State, as Diocletian passed an imperial edict exempting severely crippled arthritics from all public burdens. Caius Aurelianus in the fourth century A.D. gave an excellent description of sciatica as a typical manifestation of arthritis, and accurately described the formation of tophi in gout. He considered the disease to be of gastro-intestinal origin with an hereditary predisposition. Alexander of Tralles described many varieties of arthritis and mentioned particularly intra-articular effusions and synovial swellings. Aëtius, in the sixth century, recommended massage and passive motion, and with his contemporary, the aforementioned Alexander, was high in the praise of colchicum. Paulus Aegineta regarded the intestinal tract with its disorders as a contributing cause to both gout and arthritis, which he, like most of his contemporaries, thought to be the same disease differing only in the location of the pains. He was a firm believer, as were all his predecessors, in the humoral theory but he thought that the onset of the disease was influenced by weakness of, or injury to the affected part, and also by sorrow and anxiety reacting as predisposing causes. The great Arabian physicians, Avicenna, Rhazes, Serapion, and Haly-Abas, were the only important contributors to the subject during the dark ages of European medicine, and all followed the classical humoral theory. But in 1265 Bartholomaeus Anglicus, in describing arthritis and gout, laid stress on the fact that sciatica is a symptom of arthritis and said that arthritis is a disease of the blood and consequently its treatment must be general not local.

Guillaume de Baillou, or Ballonius as he Latinized his name, differentiated arthritis and acute rheumatic fever, and gave a most vivid description of the latter. He noted that arthritis may not only affect the joints but the subcutaneous tissues, muscles, aponeuroses, and tendons, and that when serous membranes and muscle sheaths are affected there is present a viscous serosity. Rivière, in describing rheumatism, stated that when a fever is present the disease lasts from twenty to forty days ending in complete resolution and return of function, but if no fever is present the duration may be many years with permanent change. Further along in the seventeenth century, came many descriptions of arthritis, the ones most worthy of attention being Sydenham's, Hoffmann's, and Sauvage, followed by the really remarkable "De Arthritide" of Musgrave. This work of Musgrave is a classic and makes one wonder if the knowledge of focal infection should not be made to date from his time.

Before considering the focal infective theory it might be interesting to sketch briefly the advent of bacteriology from the dawn of the Christian era when Columella in "Scriptores Rei Rustici" first described minute animal-like bodies invisible to the naked eye which reproduced themselves and were capable of producing disease,—up to the first vaccine work of Pasteur. Arthanasius Kircher in Rome in 1658 apparently was our first microscopist and he described countless broods of worms not perceptible to the naked eye which he found in cholera patients. He was thus the

first to state definitely the doctrine of *contagium animatum*. Loevenhoeck, of Delft, in 1683, described germs about the teeth, bacterial chains, and clumps. Then came Francesco Redi, precursor of Schwann and Pasteur in destroying the theory of spontaneous generation, and the philosopher Robert Boyle who prophesied that the problem of infectious disease would be solved by the man who elucidated the nature of fermentation. In 1762 Plenciz of Vienna expressed the belief that bacteria were the causative factor in disease and that each malady had a distinct causative agent. Pasteur isolated the staphylococcus pyogenes in boils and the streptococcus pyogenes in septicemia in 1878 to 1879, made his first preventive vaccine for chicken cholera in 1879 and 1880, and anthrax vaccine in 1881. His work was followed up by his pupils Metschnikoff, Roux, Yersin, Calmette and Chantemesse. In 1885 Wilson first described a diplococcus in a rheumatic case with pleurisy, and in 1886 a similar description of a coccus in rheumatism was given by Doctor Mantle, his organism being grown from a serous effusion in an acutely inflamed joint.

Popoff in 1887 was able experimentally to produce arthritic lesions with streptococci. This was followed up and confirmed by Leyden, Singer, Chvostek, Thirlois, Triboulet and Coyen, Achalme, and Apert from 1894 to 1899. In 1899 Wassermann obtained streptococci from the blood, brain, and heart of a young woman who died with cerebral symptoms following chorea, which had been preceded by an acute arthritic attack. These organisms grown on culture media and injected into rabbits caused a multiple infective arthritis. The next important investigations were those on the diplococcus rheumaticus by Poynton and Paine with confirmatory work by Beaton, Walker, Ryffel, Lewis and Longcope, and Rosenow. In 1912, T. W. Hastings did complement fixation tests in chronic infective and deforming arthritis using the streptococcus as an antigen (Journal of Experimental Medicine, 1914), and he also used polyvalent antigens for complement fixation tests for streptococcus viridans infections. This work was followed up by Major, Kinsella, Swift, Thro, etc., all of them using a single strain or an attempted polyvalent strain for the work.

As a result of these investigations vaccine therapy came into wide vogue and it was hailed as a panacea for all earthly ills, and given much too promiscuously. By this I do not mean to intimate that stock vaccines are without value, but I do wish to impress the fact that haphazard use of vaccines without knowledge of the tolerance of the patient or the amount of immunity resistance present is a dangerous and unwarranted proceeding in a large percentage of cases. Autogenous vaccines were frequently made up from every possible source without any definite means of knowing whether the organism found had any relation to the disease or not. It is, of course, a well known fact that bacteria can be grown from almost any exposed part of the human anatomy and it also should be a well known fact that in the majority of cases even pathogenic types of bacteria may have no relation whatsoever to an infective process which may be going on in the individual in question. So many strains of bacteria were found

to be present in many of the individuals examined that shot-gun vaccines containing practically all pathogenic types were used in an attempt to cover every possible source of infection.

When treatment with autogenous and stock vaccines proved disappointing, nonspecific therapy in the form of foreign protein was tried out and in a considerable number of cases was found to be more successful than the vaccines that had hitherto been used. Casein, milk, and typhoid bacilli were the most successful in practical application.

There has been a great deal of experimentation with nonspecific foreign protein therapy in an attempt to produce reaction due to peptone shock. This treatment has not a constant value though there is occasionally a very brilliant result, the reason for success being that any kind of protein acts as an antigen and in cases with good resistance the complement may be so actively stimulated that the immense non-specific antibody formation is sufficient to take care of the infection. Immunity acquired as a result of treatment with any of the various antigens is, however, a specific one, and in the use of bacterin marked bacteriocidal powers are mainly against the particular organisms or protein injected. Certain nonspecific antibody formation is also present, but this is neither sufficiently strong nor constant to warrant overwhelming the patient. This type of therapy often leaves the patient with greatly weakened resistance; the initial shock may be very severe, and the temperature bizarre. In properly dosed specific vaccine therapy, the result is obtained without producing severe reactions at any time in the course of treatment, and frequently the most severe reaction in a whole series is from the minute initial dose. In specific vaccine therapy spectacular improvement is not to be expected because the very nature of the treatment presupposes a slow and gradual increase in immunity with consequent gradual improvement of symptoms.

In 1916 we started work on the arthritides under Dr. T. W. Hastings and used his Bedell strain of streptococcus, both as antigen for fixation tests, and for vaccine in the Cornell arthritic clinic. We were disappointed in following out this line of work as improvement of the cases in the clinic was not higher than thirty per cent., a figure which we found could be obtained with almost any type of therapy. In the complement fixation work, our findings with the single strain were quite inconstant as a mild case of arthritis would frequently give a complement fixation and a severe infection which apparently was similar in type might be negative. This we found was due primarily to the inadequacy of the single strain of streptococcus viridans used, and secondarily to the deleterious effect of heat on antibodies in the process of inactivating sera according to the old complement fixation technique. By the application of Dr. Hadjopoulos' active serum technique and a careful choice of polyvalent antigens of the different types of streptococci obtained from blood cultures in septicemia cases, we think we have surmounted some of the difficulties that stood in our path as far as the diagnostic fixation tests are concerned. By polyvalent antigens we do not mean many strains of streptococci mixed together and

used as an antigen: but single blood culture strains that had overwhelmed all resistance in the individual and had taken on all possible characteristics of the particular groups to which they belonged. Thus our blood culture viridans and hemolytic streptococcic antigens are highly diagnostic individual strains that have been chosen because of their group attributes. The antigens, however, which we employed for the diagnostic work were not found to be successful when used as vaccines, and it seemed as if nothing practical had been accomplished by our work, as the old stock antigens originally obtained from Dr. Hastings still gave better clinical results than our new polyvalent strains.

At that time we started collecting cultures from foci of infection in arthritic cases, especially seeking such cases as cleared up after the removal of the focus, as in these the evidence seemed fairly presumptive that the infective area removed must have been a causative factor in the arthritic symptoms. These strains we felt would not be of group type but would be high'y specialized selective strains and consequently valuable for treatment rather than diagnosis.

We used these cultures after careful titration, as individual antigens and had a series of different types of streptococci from tooth, tonsil, sinus, nasopharynx, gall-bladder, intestinal tract, prostate, etc. Complement fixations done with these antigens would give fixation with only certain of the strains,—sometimes with one, sometimes with several, and we started using the strains which fixed with the patient's blood, and found the results were far more satisfactory than had been obtained with any previous method of treatment. In preparing these antigens for vaccine, heat is not employed to kill the bacteria as the effect of fifty-six degrees centigrade promotes a quick autolysis of the bacterial cell envelope; but when attenuated with phenol, bacteria remain intact for a much longer time and injections prepared in this way are actual bacterin emulsion instead of a disintegrated mass of bacterial protein. With this method of procedure, it is necessary to use a much smaller dose and frequently a patient who has taken without reaction five or more billion of a supposedly autogenous vaccine, will have a severe focal or even general reaction lasting twenty-four to forty-eight hours with a dosage of five million streptococci prepared from complement fixing strains which have been phenol attenuated. According to our present technique, thirty-five strains of streptococci of various types and from various foci are employed. A patient may give a four plus fixation to our blood culture diagnostic strains, and yet may fix only one or two of the focal strains. By this method we feel we have approached a specificity in vaccine therapy that previously had not been reached.

Each new case that comes for examination is searched most carefully for possible foci of infection. We have come to believe that the majority of such primary foci lie above the vocal cords, but in many of the cases seen all discoverable foci have been removed and in these individuals we are very apt to find a secondary focus of infection in the intestinal tract.

Any foci found are carefully cultured, the pathogenic organisms present are isolated, and such organisms as correspond to the patient's fixing strains are employed in making up a vaccine to be used in that case.

The first step in the examination of the patient's blood is to determine its complementary value, for we feel that one of the reasons for frequent failure in vaccine therapy, even when carefully employed, is that no one has taken into consideration the complementary value of the patient's blood before beginning treatment of a case. So far as we know this cause of failure has never been commented upon. For complement determination we employ the anti-sheep cell hemolytic value of human serum, as broadly this value is an index to the bacteriocidal complementary values. A certain percentage of the cases we see (six per cent. in the last thousand) are utterly deficient in complementary value and the use of vaccine is not only inadvisable but is almost sure to do such patients definite harm. We have come to feel that the complementary value of the patient's blood is one of our best indices to prognosis and we do not hesitate to tell a patient frankly that vaccines are of no value in his case if we find a complement deficiency. This complementary determination is not only of value in treating arthritis but may be used as a determining factor of prognosis in such diseases as typhoid, pneumonia, etc.

After having determined the complementary value, the case is then considered under its serological classification, the three major groups of which are as follows: (a) arthritis reacting to hemolytic streptococcus and iso-atrophic or exudative in character; this type in pure form is periarticular without actual bony involvement, (b) arthritis reacting similarly to hemolytic streptococcus but of different fixing properties; this type shows a non-bony deformity with ulnar deviation, marked atrophy, muscle weakness as an initial symptom, and is aniso-atrophic or deforming in character, (c) arthritis reacting to the viridans streptococcus and belonging to the osteoarthritic or productive form; bony change as demonstrated by x-ray is often a very early manifestation in this group. The majority of arthritic cases that are not arrested or cured early in the disease have a tendency to undergo further changes leading to mixed types, with a consequent mixed serological picture.

Certain pathologic conditions have long been known clinically to be precursors of arthritis. Serologically we have confirmed these clinical observations.

In controlling the value of the test in normal cases, the possibility of the presence of some masked focus of infection must be considered. With this point in mind, the test is not diagnostic for arthritis alone, but is diagnostic of a wide group of acute and chronic infections that give rise to antistreptococcic bodies in human sera.

Old Bartholomaeus Anglicus made the statement in 1265 that arthritis is not a disease of the joints alone but is a systemic one and we feel that this is a truth which has been too long disregarded in the treatment of the

disease. While we think that the most potent single factor we have in our control for the alleviation of arthritics is properly prepared and properly given vaccine, we do not feel that a patient is adequately treated unless general hygiene is rendered as favorable as possible; adequate care taken of the intestinal tract; tonics, cod liver oil, iron, and, in such cases as have low hemoglobin or lessened vitality, the Alpine ray employed as an adjuvant for those that are not able to get sunshine or are deficient in calcium; foci of infection, wherever and whenever found, should be removed when the patient's resistance is sufficient to make such a procedure free from danger of causing an exacerbation. We believe that the patient's resistance must be kept at the highest possible point; that elimination by skin, bowels, and kidneys must be active; that exercise should be taken; and massage given in such cases as show weakening of the muscles; but that neither should be given to a point of increasing joint pain.

In summarizing our work of the past ten years we have come to the conclusion that favorable results may be obtained in practically all such cases of arthritis as show a favorable complementary value, have no undraining focus, are not suffering from some debilitating disease such as tuberculosis, diabetes, carcinoma, and sometimes syphilis, and have patience to continue treatment over considerable periods. We do not feel that vaccine should be increased rapidly. A five million initial dose in autogenous and complement fixation vaccines is ample. We always watch the heart, weight, the patient's general condition, and particularly avoid the reactions which give weight loss and general lassitude even if in such cases it is necessary to hold the dosage throughout the entire treatment at not higher than five to ten million bacteria per injection.

Every patient coming for examination goes through a routine search for foci. A careful urine analysis and culture is made; the stool is examined and bacteriology determined; all possible sources of absorption are cultured and autogenous vaccines made when pathogenic organisms are found, these autogenous strains being combined with the complement fixing strains if they correspond in character and type. When such determinations have been made the patient's diet is regulated, the usual recommendations for general hygiene and elimination are made, the vaccine is given once or twice a week according to the response or reaction, and if progress is not satisfactory the examinations are made still more detailed by the addition of a specialist for any doubtful point.

In all vaccine treatment we feel the need of close cooperation with the internist, the otolaryngologist, and frequently the gynecologist and genitourinary specialist. The orthopaedist with mechanical appliances, correction of posture, and improvement in general weight-bearing is of vast assistance to us in many cases. From the operative viewpoint we do not, however, feel that surgical procedure should be employed with arthritics showing any activity in the joints, the danger of starting up a generalized polyarticular exacerbation being always present.

BIBLIOGRAPHY

McCURDY: "Human Origins."
KRAMBERGER, VIRCHOW } "Human Origins."—McCurdy.
SMITH, DR. ELIOT: Nubian Survey Bulletin.
GARRISON: "History of Medicine."
EWART: "Osteoarthritis," 1896.
OVID: Ep. ex Pont. 1, 3, 23.
THE HEARST PAPYRUS: U. of C.
HIPPOCRATES: 1525.
GALEN: Opera, Venice, 1490.
ARETAEUS: "Causes and Symptoms of Chronic Diseases." Sydenham Society Translation.
TRAGO PODAGRA: Lucien of Saramosta. Opera.
AURELIANUS CAELIUS: De Medicina. Florence, 1478; De Morbis Acutis et Chronicis. Book V, Chapter II.
ALEXANDER OF TRALLES: Latin-Greek text. Basle, 1556; Medicae artis principes. Paris, 1567.
AEGINETA, PAULUS: Opera. Paris, 1532.
BAILLOU: Opera Omnia. Tomiv. Liber de Rheumatismo. Paris, 1642.
RIVIERE: Opera Omnia, 1674. Book XVI, Chapter III.
SYDENHAM: Bohn Translation.
HOFFMANN: Opera Omnia, 1748.
SUAVAGES: Nosologia Methodica, Paris, 1763.
ANGLICUS, BARTHOLOMAEUS: De proprietatibus rerum. Cologne, about 1472.
MUSGRAVE: De Arthritide. 1703, 1707.
COLUMELLA: Scriptores Rei Rusticae. Venice, 1472.
KIRCHER, ARTHANASIUS: Scrutinium Pestis, 1658.
LEEUWENHOECK: Opera omnia. Leyden, 1722.
REDI, FRENCESCO: Experientia Circa generationem insectorum. Amsterdam, 1671.
BOYLE, ROBERT: Nova Experimenta, 1669.
SERAPION, THE YOUNGER: Liber de Medicamentis simplicibus. Strassburg, 1531.
AVICENNA: Canones, Milan, 1473.
LUCIAN: Opera, Latin and Greek. Paris, 1615.
VON PLENCIZ, MARCUS ANTON: Tractatus 1, 2, 3, Des Scarlatina, 1762.
PASTEUR: Oeuvres de Pasteur, Masson, Paris, 1924.
METCHNIKOFF: Immunity in Infective Diseases, 1907.
ROUX: Annals de l'Inst. Pasteur, 1895.
YERSIN: Annals de l'Inst. Pasteur, 1895.
CALMETTE: Annals de l'Inst. Pasteur, 1895.
CHANTEMESSE: Annals de l'Inst. Pasteur, 1895.
WILSON: Edinburgh Med. J., XXX, II, 1105–1107, 1885.
MANTLE: Brit. Med. J., I, 1381–1385, 1887.
LEYDEN: Deutsche Med. Wchnschr., 1894.
SINGER: Aetiologie, U. Klin. des Acuten Gelenkrhumatismus, 1898.
CHVOSTEK: Wein. klin. Wchnschr. 1895.
THIROLOIX: Compt. rend. Soc. de biol., 882–884, 1897.
TRIBOULET ET COYEN: Compt. rend. Soc. de biol., 1898.
ACHALME: Annales de l'Inst. Pasteur, 1897.
APERT: Compt. rend. Soc. de biol., 128–129, 1898.
WASSERMANN: Berl. klin. Wchnschr., 1899.
POYNTON AND PAINE: "Researches on Rheumatism." McMilan, 1914.
BEATON AND WALKER: Brit. Med. J., I, 237–239, 1903.
WALKER AND RYFFEL: Brit. Med. J. II, 659–660, 1903.
LEWIS AND LONGCOPE: Am. J. Med. Sc., CXXVIII, 601–611, 1904.

ROSENOW: Journal of Infectious Diseases, XIV, 61, 1914 (and others).
HASTINGS, T. W.: J. Am. Med. Assn., LX, 1208–1209, 1913.
HASTINGS, T. W.: J. Exper. Med., XX, 52–80, 1914.
MAJOR: Bull. Johns Hopkins Hospital, XXIII, 326–332, 1912.
KINSELLA: Bacteriologic Studies in Subacute Streptococcus Endocarditis, Arch. Int. Med. XIX, 367–380, March, 1917.
SWIFT, H. F. AND THRO, W. C.: A Study of Streptococci with the Complement Fixation and Conglutination Reactions, Arch. Int. Med. VII, 24–37, January, 1911.
BILLINGS: "Focal Infection."

NOTE: Discussion on this paper will appear in the next issue of the *Journal*.

THE MECHANISMS INVOLVED IN THE REMOVAL OF COLLOIDAL AND PARTICULATE CARBON FROM JOINT CAVITIES.*

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In order that joints may continue to function normally over a period of years some mechanism for the removal of waste material from joint cavities is necessary, because in the wear and tear of every day use, bits of the cartilage or synovial surfaces are detached and set free in the synovial cavity; and the gradual accumulation of this waste material would eventually interfere with the function of the joint. In pathological joints the need of an automatic cleaning system is even more urgent because injury or disease of a joint is always followed or accompanied by a cellular synovial exudate, and it is necessary that this material be removed before the joint can return to an approximately normal condition.

The problem of the drainage of joints involves the removal of particulate matter, colloid material, and true solutions. I have not found any observations in the literature on the manner in which inert foreign material is removed from synovial cavities. This paper will be limited to a description of the methods by which colloidal carbon and carbon aggregates are removed from the joint. The consideration of true solutions and finer colloids will be reported in a later paper.

MATERIAL AND METHODS

The material used was Higgins' American India ink. This is a rather coarse colloidal solution of carbon, and contains some larger particles. After it was injected into the joint many carbon aggregates were formed in the synovial exudate. The ink was filtered to remove the larger particles and was then diluted with an equal amount of distilled water and sterilized by boiling. The animals used were normal adult rabbits. In making the injections the rabbits were anaesthetized with ether and the injection was made through the skin and directly into the knee joint. About one and one-half cubic centimeters was injected into each knee. The animals were sacrificed at intervals of from one to one hundred and four days after the injection. In most instances the joint was opened and the fluid in the joint was studied supravitally, and portions of the synovial membrane and capsule were excised and imbedded in paraffin and stained. The joint was then decalcified, impregnated with celloidin and sectioned and stained. In other instances the joint was injected with ten per cent. formaldehyde and then decalcified and impregnated with celloidin and sectioned and stained. The head of the humerus was sectioned in some of the animals to

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determine whether or not the ink entered the general circulation and was deposited in the bone marrow.

OBSERVATIONS

The injection of carbon into the joint caused a rather cellular synovial exudate which was most marked on the second day after the injection and then gradually disappeared. During the first two days after the injection, over eighty per cent. of the cells in the exudate were leucocytes; but in the later exudates the proportion of leucocytes gradually decreased, and after the twelfth day the majority of the cells in the joint fluids were cells of the macrophage series (monocytes, clasmatocytes, indeterminate macrophages, and primitive cells). The cytology of the exudates and the reactions of the joint to the mild irritant are being reported elsewhere.

By the fifth day after the injection there was very little free carbon in the joint fluid but nearly all of the macrophages were loaded with it, and many of the leucocytes contained a few carbon particles. There was also a variable amount of extracellular carbon which was held in fibrin clots which might or might not be adherent to the synovial surface.

From our studies it was possible to recognize four different methods by which the carbon was removed from the joint cavity: (1) some carbon passed directly through the synovial surface, (2) carbon particles entered the lining cells of the joint, (3) the leucocytes and macrophages phagocytized carbon and carried it out into the subsynovial tissues, and (4) fibrin clots containing carbon became adherent to the synovial membrane and were invaded by living cells and a new synovial membrane was formed on their free surface, thus removing the carbon from the joint cavity. These four methods will now be described in detail.

1. *The passage of carbon directly through the synovial membrane.* After the colloidal carbon was injected much of it was precipitated and adhered to some parts of the synovial membrane, forming a dense black surface layer. This occurred most frequently in areas where the subsynovial tissue was loose in structure, such as the posterior capsule and the margins of the quadriceps pouch, but a thin layer of carbon was often present on dense areas of the joint surface.

In the loose areas the line between the synovial surface and the adherent carbon remained fairly well defined, but even on the first day after the injection a few minute granules of carbon were seen in the tissues immediately beneath the synovial surface. In addition to the occasional extracellular masses there was in some places a faint diffuse brown staining of the intercellular tissue immediately beneath the surface (Fig. 1). This brown staining was apparently due to the presence of colloidal carbon in the tissues. In areas where the synovial surface was loose in structure, but where there was no carbon sticking to the surface, the same phenomena were noted but they were less in degree. On the second and third days after the injection the amount of free carbon particles in the subsynovial

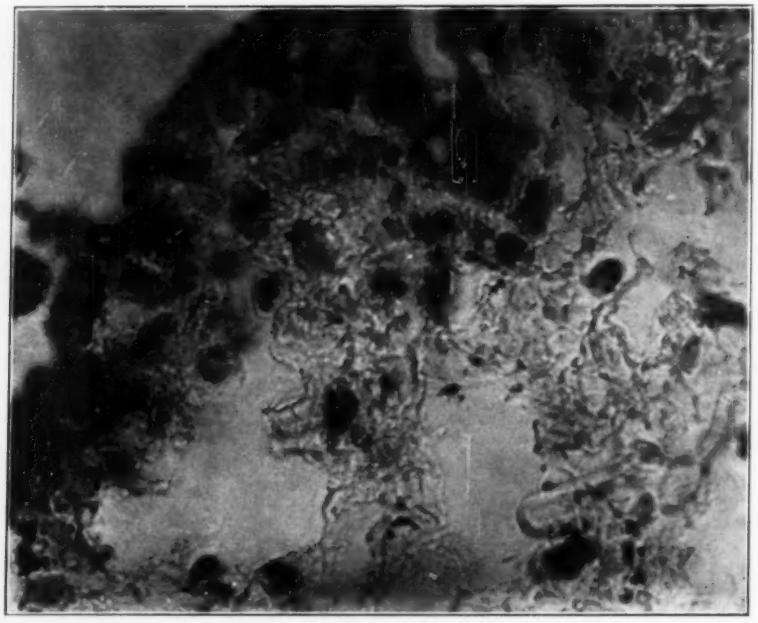

FIG. 1

Synovial surface of the lateral capsule two days after the injection. Some free carbon is sticking to the surface and is free in the subsynovial tissues both as discrete granules and as a diffuse staining of the tissues. Carbon granules are present in the synovial cells and in leucocytes and macrophages in the tissues and in the joint cavity. 3 m.m. objective.

tissue was slightly increased, and in some areas the faint brown staining of the intercellular tissues extended twenty microns or more beneath the surface. In the joints which were examined four or more days after the injection the brown staining of the colloidal carbon was less evident but there was a variable amount of carbon in the form of granules or larger masses which was free in the tissues. As will be shown later, however, it is probable that most of this carbon had been carried through the synovial surface by the phagocytic cells.

Further evidence that some of the free carbon penetrated the synovial surface was obtained by an examination of the lymph nodes which drain the joint. No carbon was seen in the inguinal nodes, but the large popliteal node constantly contained a considerable amount of carbon which had a tendency to be localized in one side of the gland. In the lymph node the carbon granules were seen in the phagocytic cells which were attached to the walls of the sinusoids and in the free macrophages (Fig. 2). During the first two weeks after the injection there was a gradual accumulation of carbon in the lymph nodes, but there was little variation in the amount of carbon in the lymph nodes which were examined at longer intervals after the injection.

In the dense areas of the joint surface (cartilage, fibrocartilage, and

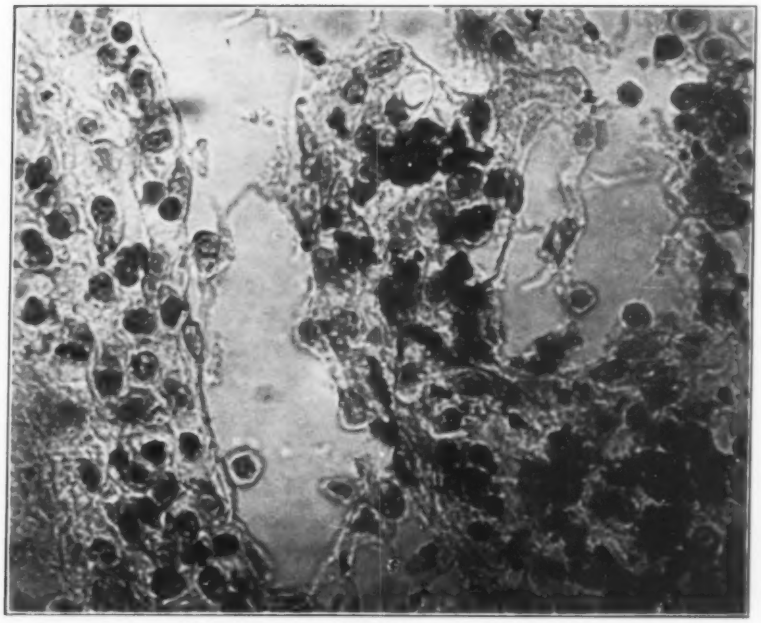

FIG. 2

Popliteal lymph node seven days after the injection. Carbon granules in the reticular cells and in macrophages. 3 m.m. objective.

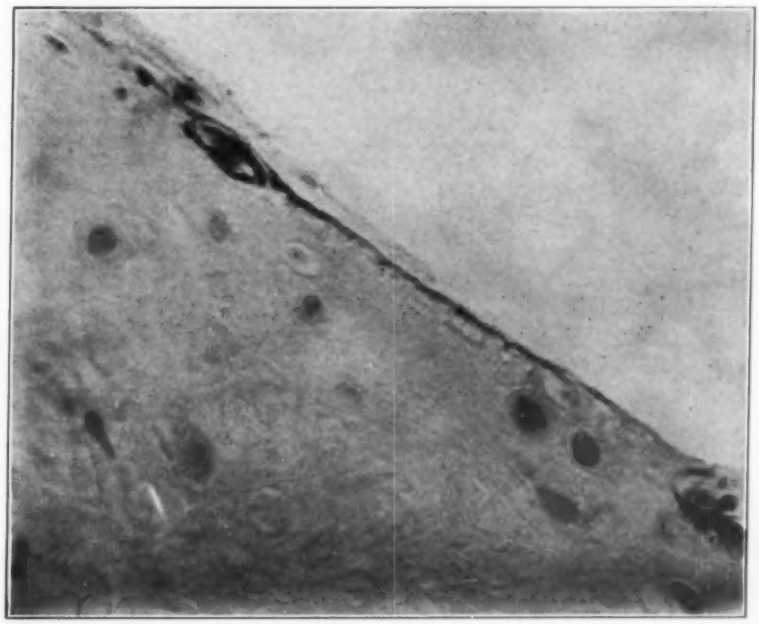

FIG. 3

Fibrocartilage three days after the injection. There is no penetration of the surface by free carbon or by carbon laden phagocytes. 3 m.m. objective.

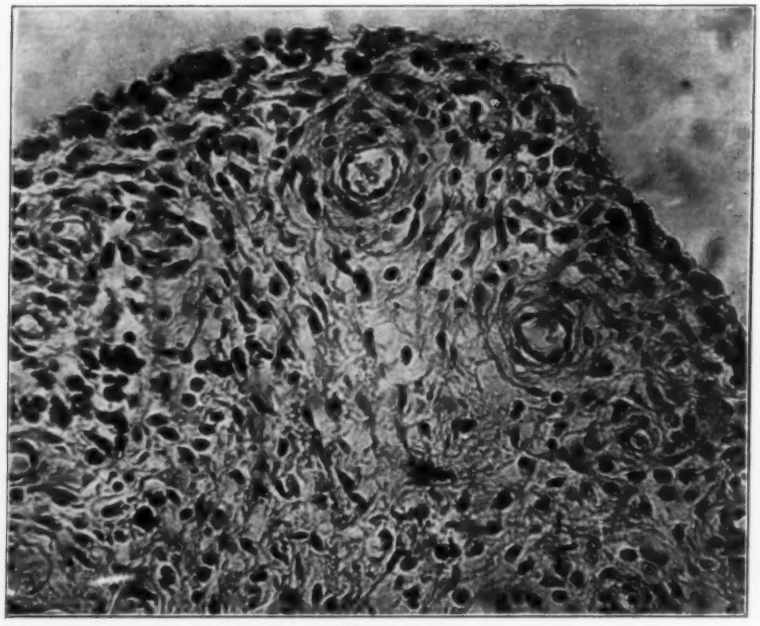

FIG. 4

Hypertrophied synovial membrane of the quadriceps pouch eight days after the injection. The surface cells contain large amounts of carbon. 4 m.m. objective.

dense fibrous tissue) there was no visible penetration of the intact surface by the India ink (Fig. 3). However, in areas where the surface of the cartilage had been injured by the needle at the time of the injection the ink infiltrated the cartilage for a short distance around the path of the needle.

In most of our joints the total amount of free carbon which passed through the joint surface was apparently very small. However, if the injection was made under too great pressure the integrity of the synovial surface was destroyed and the ink was extravasated into the tissues. This occurred in three of our joints and in each instance it was the delicate synovial membrane lining the upper end of the quadriceps pouch which was ruptured and the ink infiltrated the surrounding muscle and intermuscular areolar tissue.

2. *Absorption of carbon by the synovial lining cells.* In the joint examined on the day after the injection of the ink, many of the cells in the synovial membrane which reached the surface were found to contain a few minute carbon granules. In a joint examined five days after the injection the surface cells on the loose areas of the synovial membrane had increased considerably in size and number, and projected into the joint cavity. These cells contained considerable amounts of carbon and in the sections resembled the engorged macrophages which were fixed while passing back through the membrane into the subsynovial tissues. The surface cells on the average contained much more carbon than did the fixed connective tissue cells of the subsynovial tissues (Fig. 4).

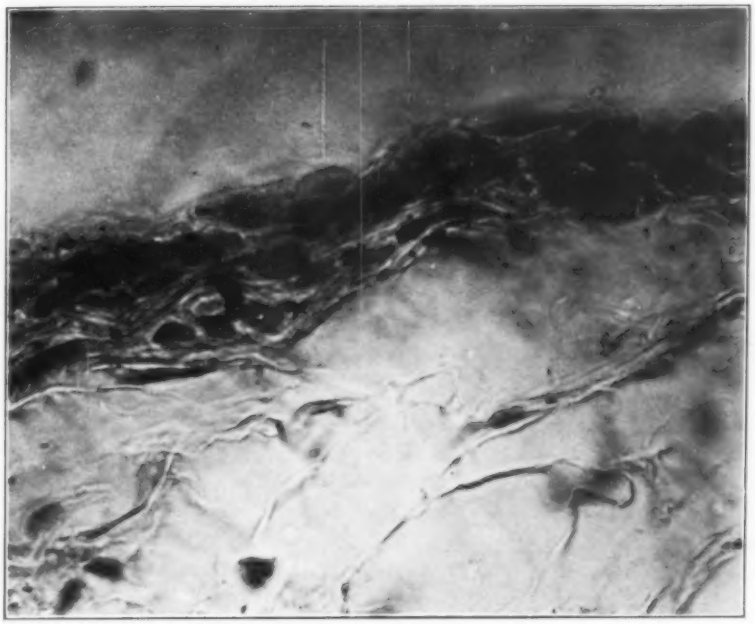

FIG. 5

Surface of the lateral capsule 104 days after the injection. The synovial cells contain a moderate amount of carbon. 3 m.m. objective.

FIG. 6

Masses of fibrin in the joint cavity four days after the injection. The lower mass is adherent to the synovial surface and is being invaded by fibroblasts, phagocytes, and young blood vessels. 16 m.m. objective.

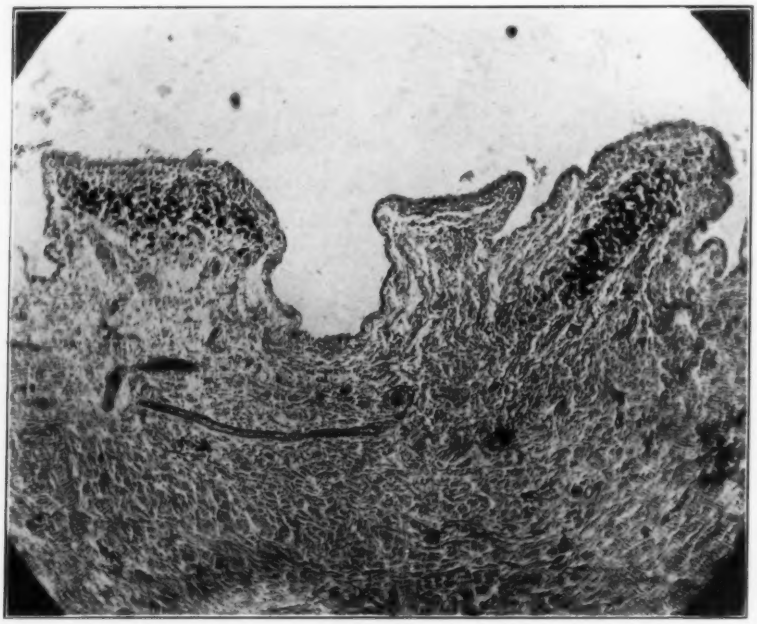

FIG. 7

Collections of carbon filled macrophages in the subsynovial tissue of the lateral capsule, 22 days after the injection. 16 m.m. objective.

Most of the free carbon had been removed from the joint cavity by the sixth day after the injection, and the joint fluids of the ten and twelve day joints contained practically no free carbon, but carbon was present in the synovial lining cells of all of the later joints. This is interpreted as evidence that these cells were not acting as pathways for the migration of carbon from the joint cavity through the cells and into the subsynovial tissues, but that they took up a small part of the carbon which reached them and tended to retain it indefinitely. There was, however, some loss of the ingested carbon by the surface cells, as in the later joints these cells contained much less carbon than did those of the joints which were examined during the first fifteen days after the injection. Figure 5 shows a small area of the synovial surface of a joint which was studied 104 days after the injection. It is seen that the surface cells still contain a moderate number of carbon granules. In the more dense areas of the joint surface, the surface cells did not hypertrophy and took up little or no carbon. The surface cells of the dense fibrous tissue, such as ligaments and tendons, often contained a few minute black granules, but the cells of the cartilage are separated from the surface by a thin layer of dense fibrous tissue and as the ink did not penetrate this tissue, the surface cells of intact cartilage contained no carbon.

3. *Removal of carbon by wandering phagocytic cells.* This is the method by which most of the injected carbon was removed from the joint cavity. Studies of the joint exudates showed that during the first five days

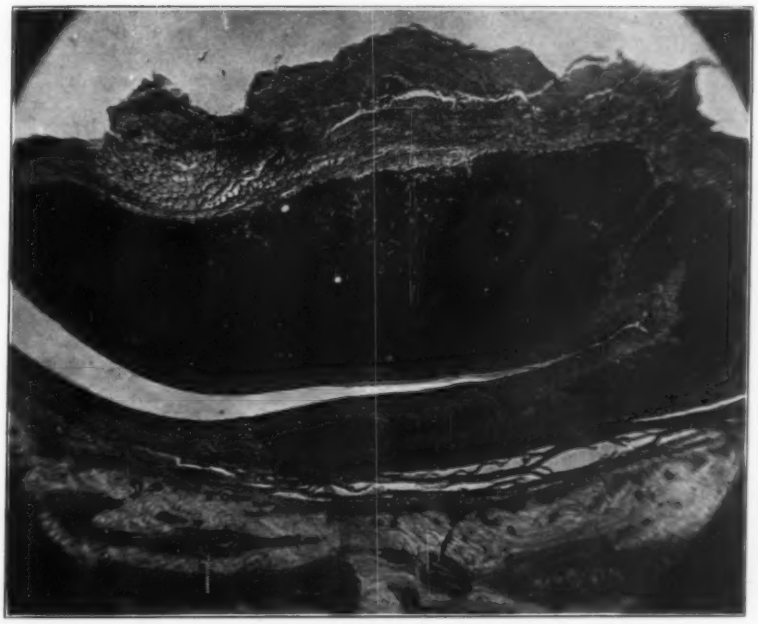

FIG. 8

Section of the lateral joint space 12 days after the injection. The side of the femur is below. The subsynovial tissues contain an unusually large number of carbon filled macrophages. The outline of the mass of macrophages is limited by the fibrous capsule of the joint. 16 m.m. objective.

after the injection, about twenty per cent. of the leucocytes and about ninety-five per cent. of the macrophages contained carbon granules. In the joints examined at from six to fifteen days after the injection, less than five per cent. of the leucocytes and more than eighty per cent. of the macrophages contained carbon. Not only did a greater percentage of the macrophages take up the carbon, but the individual cells often contained more carbon than could a dozen or more leucocytes. The leucocytes usually contained two or three small black granules, but the macrophages were so loaded with the ink that they appeared as large black masses in which the nucleus could be distinguished only with difficulty. It is thus evident that the greater part of the carbon was phagocytized by the macrophages.

On studying the sections of the joints, it was evident that these cells actively transported the ingested material from the joint cavity to the subsynovial tissues. In a joint examined on the day after the injection there were a few carbon containing leucocytes and macrophages in the loose subsynovial tissues and they could be found in various stages of migration through the synovial surface. In the two day joint the number of such cells in the subsynovial tissue was markedly increased, and in the three, four, and five day joints there were enormous numbers of carbon laden macrophages in the loose tissues beneath the synovial surface. After the fifth day the number of carbon containing leucocytes in the tissues around

the joint slowly decreased, but the number of macrophages increased up to about the fifteenth day and then slowly decreased. However, in the joint examined 104 days after the injection, there were large numbers of engorged macrophages in the tissues around the joint.

The number of carbon laden phagocytic cells which passed through any particular area of the joint surface varied inversely with the density of the given area. The migration was most marked in those areas where the synovial membrane rests upon loose areolar tissue. For this reason the greatest number of carbon laden phagocytes were found beneath the synovial membrane at the points where it is reflected from the side of the femur to the lateral capsule of the joint. There were also large numbers in the tissues of the lateral and posterior capsules, on the side of the femur, and around the quadriceps pouch. The migration into the fat pads and muscle was less extensive than in the areas mentioned above, and there was no migration of phagocytic cells into the cartilage or dense fibrous tissue areas of the joint surface.

4. *The removal of carbon by the organization of masses of fibrin which contain free carbon.* Masses of coagulated fibrin were found in many of the joints which were examined within ten days after the injection. In some instances these were free in the joint cavity, but as a rule they were adherent to the synovial surface at one or more points. The coagulated masses contained a variable amount of free carbon and living and degenerating phagocytic cells. Of these cells the leucocytes often contained a few carbon granules, and practically all of the macrophages were loaded with black granules.

In the joints which were examined four or five days after the injection the process of organization of these adherent masses was easily followed. At the point where the clot was adherent to the synovial membrane, the synovial lining cells had lost their characteristic orientation and resembled fibroblasts which were wandering out into the clot (Fig. 6). It was not possible to determine which of these invading cells had been synovial lining cells and which of them had been young subsynovial connective tissue cells. Thus the original surface line of the joint was obliterated and the clot gradually merged into the loose subsynovial tissue. At the margins of the adherent mass the synovial surface was intact and could usually be followed for some distance beneath the clot, but the surface line gradually became less distinct and then disappeared entirely. In addition to the synovial cells and fibroblasts the clot was also invaded by macrophages and young blood vessels. By studying sections of clots in the various stages of organization, it was evident that some of the invading connective tissue cells reached the free surface and became oriented along this surface to form a new synovial membrane which became continuous with the original joint lining on all sides. Thus the entire mass was removed from the joint cavity, though it might project into it until the clot was finally organized and the fibrin absorbed, after which the joint surface gradually regained its original contour.

The amount of carbon which was removed by this method varied in different joints. In some joints large adherent masses were found in the quadriceps pouch and in the posterior capsule, while in other joints which were examined at the same, or nearly the same, intervals after the injection only a few small clots were found. The coagulated fibrin did not adhere to the cartilage or dense fibrous areas of the joint but became attached only to the loose areas of the synovial surface, and was usually found in the quadriceps pouch or in the posterior capsule where it was not so liable to be broken off by joint movements.

FATE OF THE INJECTED CARBON

From what has been said above it is evident that, depending upon the method by which the carbon has left the joint cavity, it is immediately afterwards to be found in one of the following situations: (1) free in the subsynovial tissues, (2) in the synovial lining cells, (3) in leucocytes and macrophages, and (4) in extra synovial masses of fibrin. From our sections we have attempted to determine the ultimate fate of the carbon which is found in each of the above situations.

1. *The carbon which passed through the synovial surface and emerged in the tissues as free carbon.* Part of this was taken up by the surrounding connective tissue cells and any wandering phagocytic cells, either leucocytes or macrophages, which might be in the vicinity. It is probable, however, that the greater portion of this free carbon was taken up by the lymphatics and transported to the large popliteal lymph node (Fig. 2). In the lymph node most of it was engulfed by the phagocytic cells, but it is possible that some of the carbon passed through the lymph node and reached the general circulation. As carbon which is injected into a vein is deposited in the bone marrow, we searched the marrow of the humerus in some of our animals in an effort to determine whether or not the carbon injected into the knee joint had entered the circulation. We found no carbon in the humerus in any of our early experiments, but did find it in the marrow of animals examined three weeks or more after the injection. This was evidence that no large amount of the carbon had passed through the intact synovial surface and had entered the circulation, but did not preclude the early entrance of small amounts of the material into the blood stream, as it may have been deposited elsewhere.

2. *The carbon which was taken up by the lining cells of the joint.* As our longest experiment was only 104 days we do not know how long the carbon may persist in the synovial lining cells, but in all of our longer experiments most of these cells contained a moderate number of carbon granules (Fig. 5). The average amount of carbon per cell in the joints which were examined at intervals of from 30 to 104 days after the injection was, however, considerably less than it was in the joints which were examined during the first fourteen days after the injection. This is evidence that some of the carbon gradually left the synovial cells, but there was no

FIG. 9

Lateral capsule nine days after the injection. The carbon filled macrophages have not penetrated the fibrous capsule, but are massed along its inner surface and lie in the subsynovial tissues. 8 m.m. objective.

evidence to show whether it was returned to the joint cavity or passed back into the subsynovial tissues.

3. *The carbon which was carried out of the joint by the phagocytic cells.* As was stated above most of the carbon was phagocytized in the exudate and carried out of the joints by the leucocytes and macrophages. From our observations we are able to make a rather sharp distinction between the reactions of these two types of wandering phagocytic cells.

The leucocytes wandered out of the blood vessels and entered the joint in great numbers during the first two days after the injection, and then gradually disappeared as the free carbon was removed from the joint fluid. They were only moderately active in removing the carbon from the joint, as at no time were over twenty-five per cent. of the leucocytes in the synovial exudates seen to contain carbon, and the amount of the material which a single leucocyte ingested was, as a rule, very small. After the fifth day less than five per cent. of the leucocytes contained carbon granules.

In vital preparations we have watched living leucocytes expel ingested carbon granules and wander off. It is thus evident that a leucocyte may deposit its ingested carbon in the joint cavity, in the tissues around the joint, or even return with it to the blood stream.

The macrophages, on the other hand, are normal inhabitants of the synovial fluid and the adjacent loose subsynovial tissues. Of those present at the time of the injection practically one hundred per cent. became

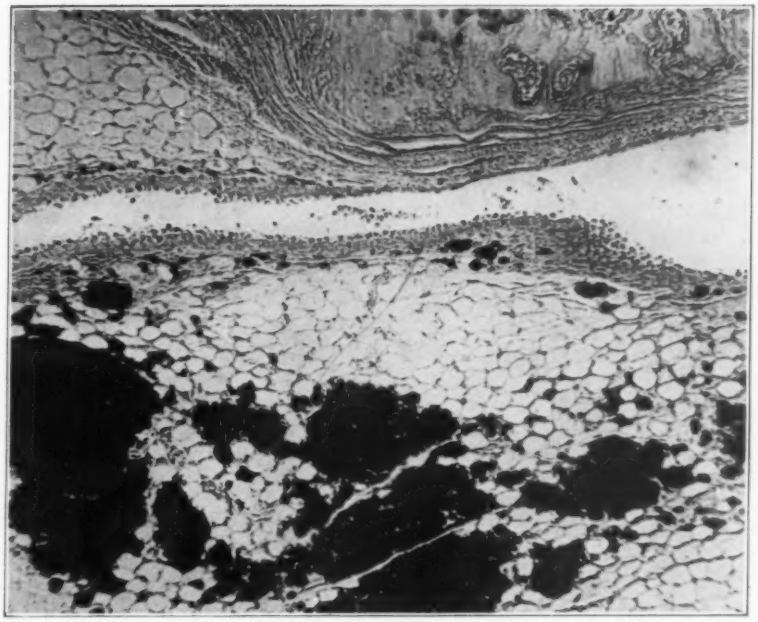

FIG. 10

Posterior capsule 104 days after the injection. There are large masses of free carbon and carbon filled macrophages in the fat tissue and these are not encapsulated by fibrous tissue. 16 m.m. objective.

engorged with carbon granules. During the first two days after the injection the leucocytes were the predominating cells in the exudates, but after this time the macrophages arrived in increasing numbers and the character of the exudates gradually changed until by the fifteenth day after the injection most of the cells were macrophages. It is probable that the macrophages were formed in the tissues around the joint and this explains the delay in their appearance. As long as there was any free carbon present the macrophages phagocytized it in great numbers.

In studying hundreds of vital preparations we have seen no evidence that living macrophages can ever expel ingested carbon. If the ingested material cannot be digested by the cell it apparently remains in the protoplasm of the macrophage until the cell dies and disintegrates, when the material is again set free in the tissues, or joint cavity, as the case may be. Thus the fate of the carbon which was phagocytized by the macrophages was the fate of the macrophages which contained it. As these are wandering cells we would expect the carbon to be widely disseminated through the body, but such was not the case. The engorged cells which had wandered out of the joint cavity settled down in the subsynovial tissues within a short distance of the joint surface, and remained dormant for an indefinite period. They exhibited a definite tendency to clump together in the tissues and form dense black masses of carbon-filled cells (Fig. 7).

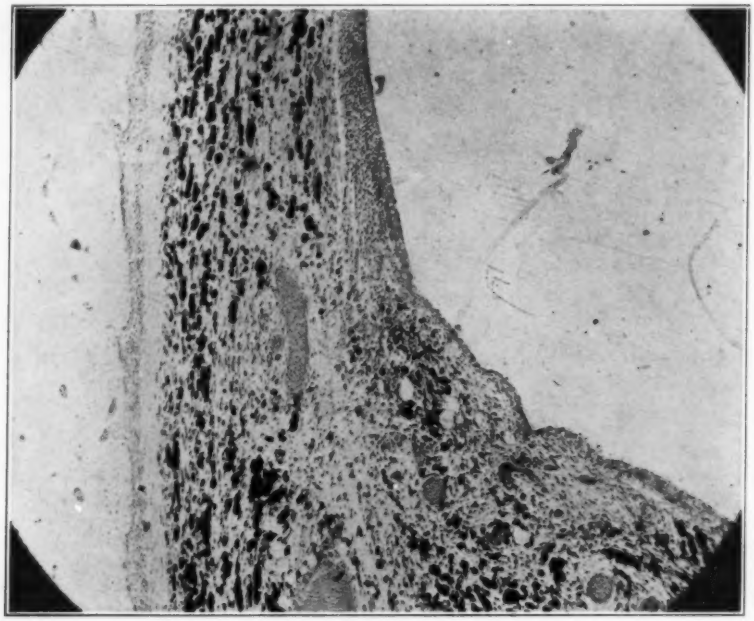

FIG. 11

Side of the femur 18 days after the injection. Femur on the left and synovial surface on the right. The carbon filled macrophages have not penetrated the fibrous layer of the periosteum. 16 m.m. objective.

As the macrophages are apparently unable to penetrate rather dense fibrous tissue, the final resting place of many of them was close to the inner surface of the fibrous capsule which bounds the lateral aspects of the joint. Here they formed a dense black layer (Fig. 8) of carbon-filled cells. Many of them, however, came to rest and degenerated in the loose subsynovial tissue which lies between this capsule and the synovial surface (Fig. 9).

In areas where the synovial membrane rests upon fat tissue, the macrophages showed a marked tendency to form clumps immediately beneath the surface, though some of them penetrated deeply into the fat tissue (Fig. 10).

In most places the fibrous layer of the periosteum acted as an effective barrier to the invasion of the bone by the carbon filled macrophages (Fig. 11), but at points where the Volkmann's canals open on the surface of the bone the fibrous layer of the periosteum is rather loose in structure, and in such areas carbon containing macrophages were seen beneath the fibrous layer of the periosteum, in the canals, and even in the adjacent bone marrow. This penetration of the bone by the carbon laden macrophages was seen to occur as early as the fifth day after the injection and was noted in all of the longer experiments. The most frequent points at which the bones were invaded were the posterior surface of the lower extremity of the femur where the cortex and periosteum are very thin and close to the joint surface (Fig. 12), and near the cartilage margins of all of the bones

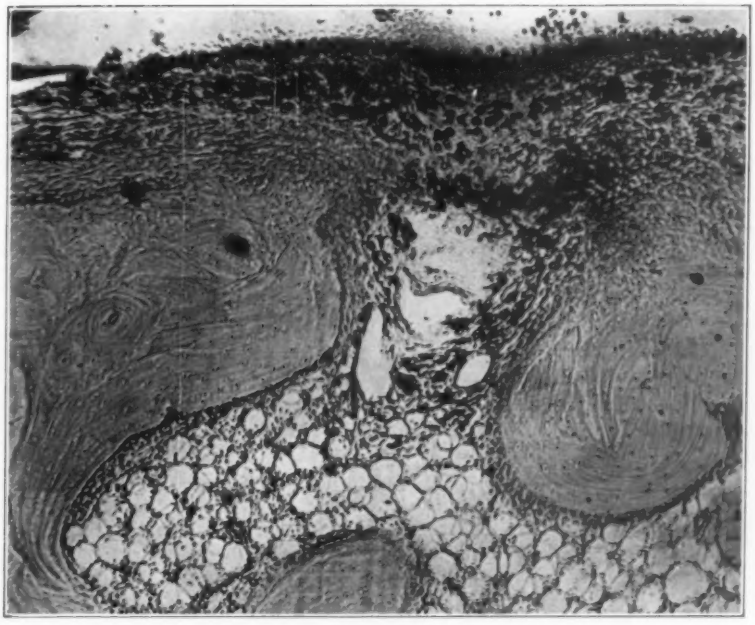

FIG. 12

Posterior surface of the femur 15 days after the injection. Synovial surface above. The carbon filled macrophages have wandered into the Volkmann's canal and reached the bone marrow. 8 m.m. objective.

of the knee joint, where rather large canals perforate the cortex (Fig. 13). It is interesting that in no instance was there any penetration of the bone at the epiphyseal line, as this is bridged by a rather dense fibrous layer of the periosteum (Fig. 14).

In one joint in which a considerable amount of carbon had gotten beneath the fibrous layer of the periosteum, a rather large exostosis was present on the side of the femur. This was apparently due to the irritant effect of the carbon on the osteoblasts (Figs. 15 and 16).

The transportation of the inert carbon from the joint cavity to the bone marrow gives us a definite idea as to the method by which infections in the joint may reach the bone.

4. *The carbon in the masses of coagulated fibrin which were bodily excluded from the joint cavity.* These fibrin masses were invaded by macrophages and fibroblasts. Most of the fibroblasts took up a few small carbon granules, and the macrophages became engorged with carbon and either clumped together in the immediate vicinity or wandered off in the subsynovial tissues.

From what has been said above it is evident that throughout the duration of the experiment the carbon laden macrophages remained in the loose tissues around the joint and were constantly degenerating and setting the carbon free in the tissues. Some of this carbon was again phago-

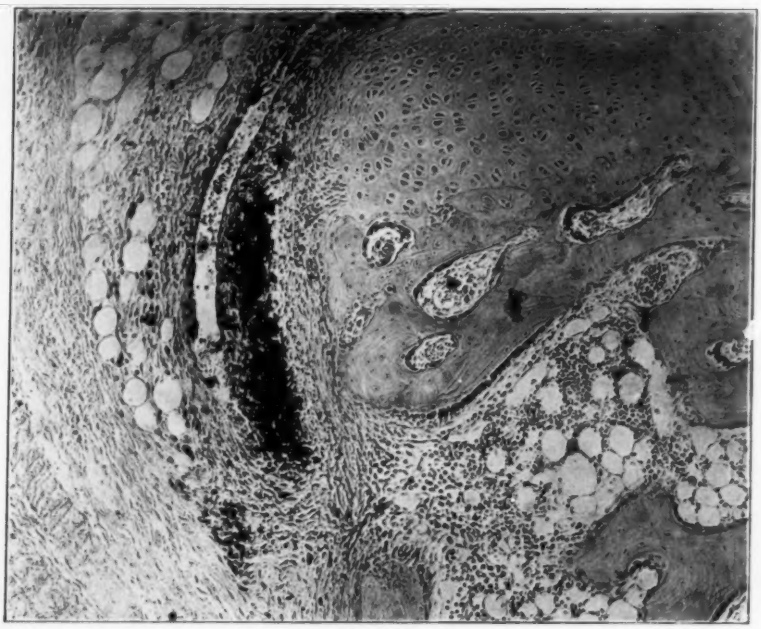

FIG. 13

Border of the patella five days after the injection. A few carbon filled macrophages have entered the Volkmann's canal. 8 m.m. objective.

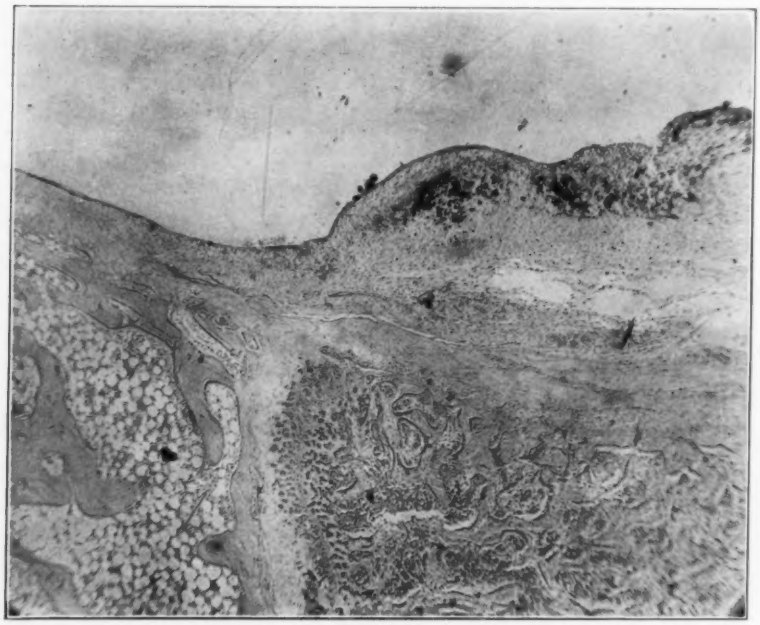

FIG. 14

Side of the femur five days after the injection. The fibrous layer of the periosteum crosses the epiphyseal line and protects it from invasion by carbon filled macrophages. 16 m.m. objective.

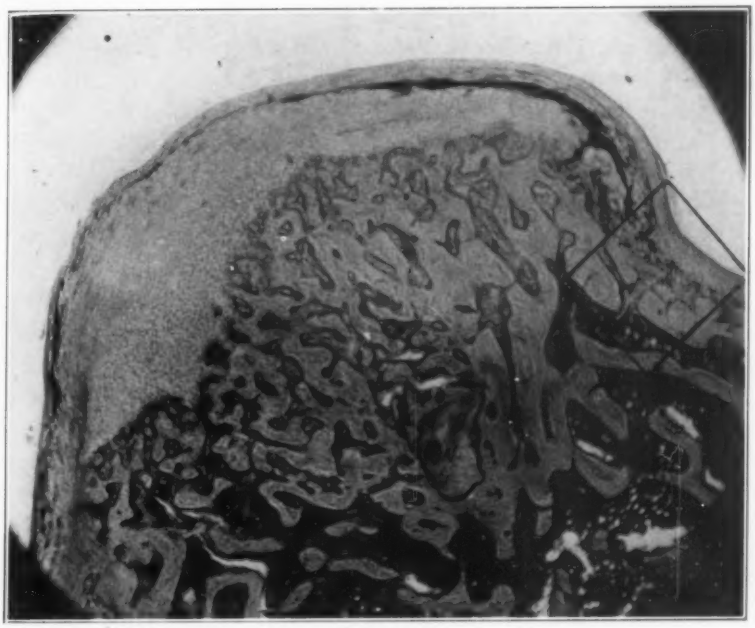

FIG. 15

Exostosis on the side of the femur sixty days after the injection. The dark line beneath the surface is a zone of free carbon and carbon filled macrophages. 16 m.m. objective.

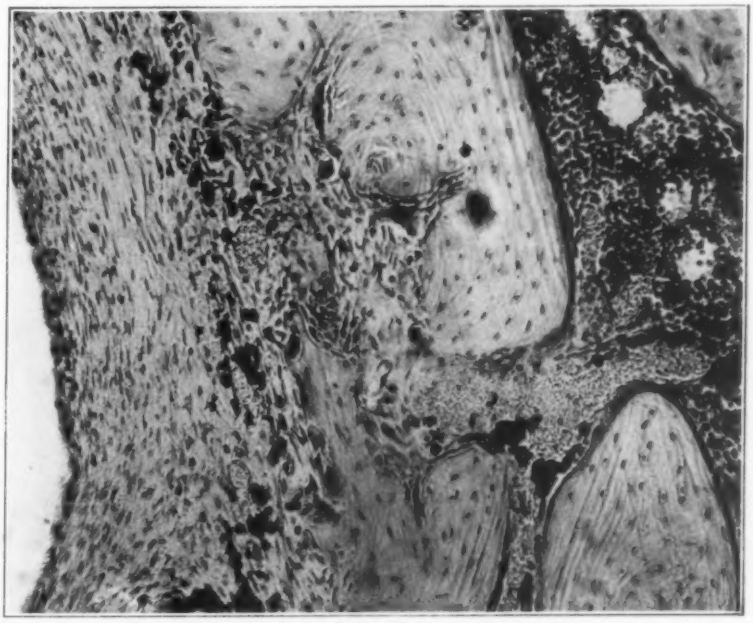

FIG. 16

Area on the anterior border of the exostosis which is outlined in Fig. 15. The carbon filled macrophages are seen beneath the periosteum, and in the bone marrow. 4 m.m. objective.

cytized by other macrophages, some of it entered the protoplasm of almost any cells with which it came in contact, and some of it entered the blood stream and was carried to the reticulo-endothelial cells of the bone marrow. In areas where there was free carbon in the tissues around them, the black granules were constantly found in young and adult connective tissue cells, in osteoblasts, and in osteoclasts; and were occasionally seen in fat cells, cartilage cells, bone cells, and leucocytes; and were very rarely seen in the endothelial cells of small blood vessels and in the small round cells (primitive cells or lymphocytes?).

In the synovial fluid of the joint which was examined 104 days after the injection the cell content was normal, but seventy per cent. of the cells contained a few minute carbon granules. These cells were macrophages which had probably picked up the carbon in the subsynovial tissues and carried it back into the joint cavity. The indications are that much of the carbon traveled in an endless circle being engulfed and moved from place to place by succeeding generations of macrophages, but that it tended to remain in the vicinity of the joint for a long time, and from time to time some of it reentered the synovial cavity. In the later joints large masses of apparently extracellular carbon were scattered about in the subsynovial tissues. These masses of free carbon were not encapsulated and apparently did not irritate the surrounding tissues in any way as there was no collection of cells around them.

As was noted above, in animals which were examined three weeks or more after the injection, the reticulo-endothelial cells of the marrow of the humerus were found to contain some carbon. Our observations lead us to believe that this carbon had passed directly into the blood vessels from the subsynovial tissues and had not traversed the popliteal lymph node. The evidence on which this assumption is based is as follows: 1. The lymph nodes which were examined three or more weeks after the injection contained less carbon than did those which were examined two weeks after the injection. 2. The carbon in the lymph nodes was in the form of dense black intracellular aggregates which varied in size and shape. 3. Most of the carbon in the reticulo-endothelial cells of the bone marrow was present as a pale brown staining of the granules or vacuoles in these cells, and had evidently reached the cells as colloidal carbon. 4. Many of the dense black extracellular masses of carbon showed hazy brown outlines which gradually faded into the surrounding tissues.

The most reasonable interpretation of the above observations is that the brown halo around the black extracellular masses was colloidal carbon which was being slowly given off by them, and that this colloidal carbon passed directly into the blood capillaries and was then removed from the blood by the reticulo-endothelial system. If much of it had been taken up by the lymphatics we would expect to find increasing amounts of carbon in the popliteal notes of the longer experiments. We have seen little or no evidence that carbon aggregates entered the blood stream, but, as was noted above, carbon in this form was carried into the adjacent bones by the macrophages.

CONCLUSIONS

1. Most of the carbon which was injected into the joint cavity was phagocytized by macrophages and leucocytes, and by the tenth day after the injection the greater part of it had been carried out of the joint cavity by these cells.

2. Small amounts of free carbon passed through the intact synovial surface.

3. The synovial lining cells took up small amounts of carbon and tended to hold the ingested carbon indefinitely.

4. A variable amount of carbon was held in fibrin clots which became attached to the synovial membrane and were invaded by cells which formed a new synovial membrane on the free surface of the clot.

5. A small amount of the free carbon was carried from the subsynovial tissues to the popliteal lymph node.

6. Most of the carbon remained in the loose tissues around the joint, and much of it was repeatedly phagocytized and moved about by succeeding generations of macrophages.

7. Living leucocytes were seen to expel ingested carbon but the macrophages apparently retained the material until the cell died and degenerated.

8. The various types of connective tissue and bone cells took up small amounts of carbon and tended to hold it indefinitely.

9. Some of the carbon which was injected into the joint was eventually transported into the femur, tibia, patella, and sesamoid bones.

10. The extracellular carbon in the subsynovial tissues was slowly absorbed as colloidal carbon and was carried by the blood stream to the reticulo-endothelial system.

News Notes

The Fortieth Annual Meeting of the American Orthopaedic Association was held in Atlanta, Monday, Tuesday and Wednesday, April 26, 27, 28, 1926. One hundred and seventy-five members and guests were present. The first day was devoted to a demonstration by Dr. Hoke and his Staff of cases, results of operations, etc. The Clinic was held and a large number of cases were seen by the members and opportunity given to them to examine the cases on which the various operations had been performed. On Tuesday and Wednesday the following program was presented:

TUESDAY, APRIL 27, 1926

Morning Session, 9 a.m.

DR. WILLIAM S. BAER. End Results of Arthroplasties of the Hip.

DR. W. C. CAMPBELL. End Results of Arthroplasties of the Hip.

DR. ARMITAGE WHITMAN. End Results of the Whitman Reconstruction Operation on the Hip.

Discussion opened by Dr. Albert H. Freiberg, Dr. Fred H. Albee, Dr. A. Bruce Gill.

First Executive Session 12 m.

Afternoon Session, 2 p.m.

DR. MICHAEL HOKE. President's Address.

DR. RUSSELL A. HIBBS. Operation for Fusion of the Hip in Tuberculosis of that Joint—A Preliminary Report.

Discussion opened by Dr. E. G. Brackett, Dr. David Silver.

DR. HERBERT P. H. GALLOWAY. The Open Operation for Congenital Dislocation of the Hip; Special Reference to Results.

DR. DEFOREST P. WILLARD. End Results of Davis Manipulation in Congenital Dislocations of the Hip.

DR. BENJAMIN P. FARRELL, DR. H. L. VON LACKUM, DR. A. DEF. SMITH. Report of the End Results in 310 cases of Reduction in Congenital Dislocation of the Hip.

Discussion opened by Dr. Z. B. Adams, Dr. Robert Soutter, Dr. Frank D. Dickson.

DR. ROLAND HAMMOND. Transplantation of the Fibula to Replace Bony Defect in the Shoulder Joint.

DR. NATHANIEL ALLISON. The Nature of Synovial Fluid.

DR. J. ALBERT KEY. Methods of Removal of Particulate Material from Joint Cavities.

Discussion opened by Dr. Leo Mayer.

WEDNESDAY, APRIL 28, 1926

Morning Session, 9 a.m.

DR. PHILIP D. WILSON. The Blood Supply of the Epiphyses.

DR. ARTHUR T. LEGG. The End Results of Coxa Plana.

Discussion opened by Dr. Robert B. Osgood, Dr. Frederick C. Kidner.

DR. REGINALD BURBANK. Vaccine Therapy and Focal Infection in Chronic Arthritis.

DR. PAUL B. MAGNUSON. Protein Arthritis.

(Presented by Dr. MacDonald.)

DR. LORING T. SWAIN. Orthopaedic Principles in the Treatment of Chronic Arthritis.

Discussion opened by Dr. A. MacKenzie Forbes, Dr. W. W. Plummer, Dr. Melvin S. Henderson, Dr. L. H. Mayers, Dr. Philip Lewin.

Second Executive Session, 12 m.

Afternoon Session, 2 p.m.

Dr. David Silver. The Role of the Capsule in Joint Contractures.
Discussion opened by Dr. James W. Sever, Dr. George E. Bennett, Dr. Robert Schrock.

Dr. Charles L. Lowman. An Underwater Gymnasium.

Dr. Lawson Thornton. The Treatment of Osteomyelitis of the Lower End of the Femur.
Discussion opened by Dr. John P. Lord, Dr. Fred J. Gaenslen.

Dr. Arthur Steindler. Treatment of Scoliosis—Compensation vs. Correction.
Discussion opened by Dr. Samuel Kleinberg.

Dr. Melvin S. Henderson. Blood Chemistry in Ununited Fractures.

Dr. H. Winnett Orr. Fractures.
Discussion opened by Dr. Edwin Ryerson, Dr. Charles F. Eikenbary, Dr. Paul P. Swett.

On Tuesday evening the members and the guests of the Association were entertained at the Driving Club by Dr. Hoke.

The following officers were elected:

Dr. James B. Watkins of San Francisco being the President Elect, becomes the President for the ensuing year.

Dr. A. MacKenzie Forbes, President Elect.

Dr. John A. Porter, Treasurer.

Dr. DeForest P. Willard, Secretary.

New members were elected to the Association as follows:

Dr. LeRoy C. Abbott,
Shriners Hospital for Crippled Children, St. Louis, Mo.

Dr. R. Wallace Billington,
The Lambuth Bldg., Nashville, Tenn.

Dr. A. Barney Brooks,
5564 Enright Avenue, St. Louis, Mo.

Dr. William A. Clark,
408 Central Bldg., Pasadena, Cal.

Dr. Wallace H. Cole,
Hamm Bldg., St. Paul, Minn.

Dr. Benjamin P. Farrell,
104 E. 40th St., New York, N. Y.

Dr. A. B. LeMesurier,
160 Bloor St., Toronto, Canada.

Dr. Oscar Lee Miller,
Gastonia, North Carolina.

Dr. David E. Robertson,
112 College St., Toronto, Canada.

Dr. James S. Speed,
869 Madison Avenue, Memphis, Tenn.

Dr. Joseph E. Stewart,
819 University Club Bldg., St. Louis, Mo.

Dr. John C. Wilson,
1136 West Sixth Street, Los Angeles, Cal.

It was decided that the meeting of 1927 will be held in San Francisco, the date of the meeting to be decided later.

The Secretary presented memorials on the death, during the past year, of two members of the Association, Dr. F. Halstead Myers, and Dr. Fred J. Fassatt. In each case it was voted that the resolution be spread upon the minutes of the Association and a copy sent to the family. These resolutions appear on another page of this issue of the *Journal*.

Dr. C. F. Eikenbary, formerly of Spokane, Washington, has recently accepted the position of Chief Surgeon of the Children's Orthopaedic Hospital, in Seattle, Washington. This hospital is an important institution and serves a large territory. Dr. Eikenbary's address is Stimson Bldg., Seattle, Washington.

Dr. John C. Wilson has recently opened a new office at 1136 West Sixth Street, Los Angeles, California.

Dr. DeForest P. Willard has moved his office from 1630 Spruce Street to 1729 Spruce street, Philadelphia, Pa.

Dr. J. E. Wyant has recently moved his office to 1729 Spruce Street, Philadelphia, Pa.

Dr. Jesse B. Griffith, formerly of Monessen, Pa., is now located at 1201 Monterey Street, N. S. Pittsburgh, Pa.

Dr. C. B. Bennett is now located at the Emergency Industrial Station, 1414 San Pablo Avenue, Berkeley, California.

Dr. B. R. Kirklin, formerly of Muncie, Indiana, is now located at the Mayo Clinic, Rochester, Minnesota.

The Kansas State Medical Society met at Kansas City on May 4, 5, and 6. One morning session was devoted to a discussion of the treatment of End Results in Fractures and Joint Injuries. Dr. H. Winnett Orr of Lincoln, Nebraska, was the guest and speaker at that session.

From Shanghai the Editor recently received a program of the Sixth Biennial Conference of the National Medical Association of China, held at Shanghai in February. This Association is made up of five hundred medical men, trained either in Europe or America and now practicing in China. An extensive exhibit was a feature of the Conference. Among the interesting announcements on the varied program were the following papers, most of them presented in English:

Report of Four Years' Fractures in St. Luke's Hospital, Shanghai.	C. L. Wong.
Analysis of Thirty-Four Cases of Fracture of Elbow.	L. S. Woo.
Discussion on the Methods of Treatment for Fracture.	I. K. Wong.
An Analysis of Three Hundred Cases of Motor Car Accidents.	S. P. Koo.

The Pacific Northwest Orthopaedic Society met in Tacoma for its mid-winter clinical meeting on February 21 and 22. The organization embraces all the surgeons doing exclusively bone and joint work throughout the Northwest States.

The first day was one of initial organization and was spent aboard the yacht "Argosy" on an up-Sound cruise. Many of the members were accompanied by their ladies.

The second day was given up exclusively to clinical end results from the practice of the President, Dr. Edward A. Rich of Tacoma. The following typical cases were presented:

1. End results of simple traumatic birth hip dislocations, a class that is often confused with congenital dislocations.

2. End results in three cases of typical congenital hip dislocations one or more years after discharged from treatment. Time of treatment, second year.

3. End results of open operation for double congenital hip dislocation in twelve

year old girl, showing one hip partly ankylosed following reduction in one procedure and in the second hip a better result following a two stage operation.

4. Result of bone-pegging in fracture of the femoral neck, cases of union five or more years following operation.

5. Results in synovectomies of knee joint after specific arthritis, showing excellent weight-bearing results without pain, ankylosis in one case and fifteen degrees motion in one case.

6. Result of stabilizing operation on capsule and bones in Charcot's knee.

7. Results of Naughton-Dunn partial astraglectomies and operation for stabilizing the foot, one case of paralytic cavus and varus and one case of traumatic valgus.

8. Results ten or more years after operative procedures on paralytic lower extremities: (a) arthrodesis of knee, (b) astraglectomies and stabilizing operations, (c) stabilizing capsule operation on dislocating hips, (d) use of silk ligaments.

9. End results in Stoeffel operation for spasticities two years after surgery, compared with cases under the older treatment of tenotomies.

10. Case of polyarticular infection including involvement of the joints, all limbs and of the lumbar spine. Complete clearing up of all foci with some ankyloses.

11. Case under treatment, tuberculosis of bursae with rice body formation in both knees and both elbows, without marked constitutional symptoms. Resections.

12. Difficult case of congenital equino-varus of both feet. Poor results in one foot, after fourteen years of treatment.

13. End results of arthoplasties. Successful mobility in hip and knee in one case, three years after surgery. Case of stability following Campbell method but with only twenty degrees motion.

14. Results of Putti packing in osteomyelitis after radical excisions. One case of extensive involvement of radius and ulna near elbow. One case of involvement of tibia following infected fracture.

The Annual meeting of the **Northwest Orthopaedic Society** will be held in Spokane on June 30. Dr. Arthur Steindler will be the principal speaker and guest of honor.

The Advisory Editorial Staff. At the meeting of the American Orthopaedic Association at Atlanta in April, the Editor was authorized to establish an Advisory Editorial Staff, composed of men in different parts of the country who will represent the Journal in those sections and see that the interests of those sections are adequately represented in the Journal. It is hoped that this new plan will keep the Journal from giving undue emphasis to any one section of the country and will make it possible for its readers to be more closely in touch with the orthopaedic activities throughout the country. Additions will be made to the staff from time to time. The men who have already accepted appointment as members of this staff are:

Dr. S. C. Baldwin,
315 McCornick Bldg., Salt Lake City, Utah.

Dr. Edward C. Bull,
380 Post Street, San Francisco, California.

Dr. C. N. Callendar,
The Fargo Clinic, Fargo, North Dakota.

Dr. W. B. Carrell,
3701 Maple Avenue at Wellborn, Dallas, Texas.

Dr. R. B. Cofield,
Vindonissa Bldg., 19 West Seventh St., Cincinnati, Ohio.

Dr. Wallace H. Cole,
Hamm Bldg., St. Paul, Minnesota.

Dr. Frank D. Dickson,
1807 Federal Reserve Bank Bldg., Kansas City, Missouri.

Dr. Charles F. Eikenbary,
Stimson Bldg., Seattle, Washington.

Dr. C. B. Francisco,
Argyle Bldg., Kansas City, Missouri.
Dr. Fred J. Gaenslen,
416 Goldsmith Bldg., Milwaukee, Wisconsin.
Dr. R. I. Harris,
311 Avenue Road, Toronto, Canada.
Dr. Edward S. Hatch,
Physicians and Surgeons Bldg., New Orleans, La.
Dr. Murk Jansen,
3 Oegstgeesterlaan, Leiden, Holland.
Dr. Frederick C. Kidner,
David Whitney Bldg., Detroit, Michigan.
Dr. Philip Lewin,
7 W. Madison Street, Chicago, Ill.
Dr. Henry P. Mauck,
Professional Bldg., Richmond, Va.
Dr. Earl D. McBride,
717-723 North Robinson, Oklahoma City, Oklahoma.
Dr. Andrew P. MacKinnon,
661 Broadway, Winnipeg, Canada.
Dr. Oscar Lee Miller,
Gastonia, North Carolina.
Dr. I. William Nachlas,
2312 Eutaw Place, Baltimore, Md.
Dr. H. Winnett Orr,
223 First National Bank Bldg., Lincoln, Nebraska.
Dr. William Barnett Owen,
Francis Bldg., Louisville, Ky.
Dr. Edward A. Rich,
Rust Bldg., Tacoma, Washington.
Dr. Robert Schrock,
482 Aquila Court Bldg., Omaha, Nebraska.
Dr. James S. Speed,
869 Madison Ave., Memphis, Tenn.
Dr. Arthur Steindler,
Children's Hospital, Iowa City, Iowa.
Dr. John Wilson,
1136 West Sixth Street, Los Angeles, California.
Dr. James Wyant,
1729 Spruce Street, Philadelphia, Pa.
Dr. F. P. Yorsten,
5292 Park Avenue, Montreal, Canada.
Dr. Carl C. Yount,
Jenkins Arcade Bldg., Pittsburgh, Pa.

CLINICAL CONFERENCES AT THE HOSPITAL FOR RUPTURED AND CRIPPLED, NEW YORK CITY

CONFERENCE OF JANUARY, 1926

THE PRESIDENT, ARTHUR KRIDA, IN THE CHAIR

DR. S. KLEINBERG—Specimen of Senile Endarteritis of Posterior Tibial Artery.

Dr. Kleinberg presented the case of Hyman T., 70 years old, who was admitted to the hospital two months ago for gangrene of the right third and fourth toes. Four weeks previously he began to have pain and numbness in the right third toe. The pain

extended up the leg, was continuous and kept him awake day and night. When I examined him several days before his admission to the hospital there was distinct gangrene of the third toe and of the distal phalanx of the fourth toe. He refused amputation of the limb. Continuous baking was applied and within several weeks all of his pain disappeared and he was perfectly comfortable. Local amputation of the toes was thought inadvisable because of the fear that the wound would not heal and of the likelihood of a subsequent infection.

After the patient had been in the hospital about six weeks he finally consented to amputation and two weeks ago the limb was amputated through the middle of the leg. The wound is healing satisfactorily. About three inches of the posterior tibial artery was removed from the amputated limb. The artery and adjacent veins and the peroneal nerve were found matted together and all formed a very hard mass. The artery felt as hard as the nerve. On cross-section the lumen of the artery was completely obliterated. The walls of the veins appeared thickened. A microscopic section showed marked thickening of the artery and a complete obliteration of its lumen by a thrombus with numerous blood vessels within the thrombus indicating that a process of organization is going on.

Dr. K. Hansson—Muscle-Nerve Testing in Peripheral Nerve Lesions.

I usually employ the faradic current and the condenser set for muscle and nerve testing. In electro diagnosis we use the unipolar method, i. e., one large indifferent electrode along the spine or over the brachial or lumbo-sacral plexus and the active, negative small electrode over the motor point of the muscle. The motor point is the part of the muscle where the motor-nerve enters. In a normal muscle the motor-point is usually found in the middle of the muscle belly but in the presence of reaction of degeneration the point of maximum stimulation is displaced distally. In an unilateral lesion the normal side should be used as a control or your own extremity can be used for the same purpose.

Electro Diagnosis in Peripheral Nerve Lesion

Electro diagnosis is applicable in lower neuro-lesions. The faradic current gives us a yes or no answer to the conductivity of the peripheral nerve. To obtain a quantitative estimation of the progress of degeneration or regeneration we use Lewis Jones' condenser set. This consists of a galvanic outfit so arranged that the electrical impulses are of uniform strength but varying duration.

Prognostic and Diagnostic Value of Muscle and Nerve Testing

1. If the clinical examination is unsatisfactory because of the patient's mental condition, electro diagnosis will either confirm or correct the clinical findings.
2. In the presence of a fracture when motion causes much pain it is of value.
3. When the clinical examination shows paralysis of a group of muscles but the muscle and nerve testing shows slight response, we may consider it a partial reaction of degeneration and advise against any surgical interference. A facial paralysis without reaction of degeneration will usually recover in one month, one with reaction of degeneration may take six months or may not recover at all.
4. It will help to localize the lesion.
5. It is of distinct value in differentiating a peripheral nerve lesion from hysteria.
6. In the presence of an open wound or compound fracture. A complete reaction of degeneration after ten days should be the indication for a neurolysis.
7. The electro diagnosis chart is a permanent record and repeated examinations can show the progress of nerve regeneration and therefore is of value as to the prognosis.

We have to bear in mind that electro diagnosis is only a laboratory method and all laboratory methods should be interpreted in the light of the physical examination.

Case 1. This boy, 16 years old, had his left arm caught between the floor of the elevator shaft and the descending elevator, on November 20, 1925. The arm felt heavy and the patient was unable to move it. He saw a doctor immediately who diagnosed injury to the nerves of the forearm. He had heat and massage for three weeks without improvement and then was admitted to the Out Patient Department of this

hospital for prognosis and treatment. Physical examination showed the boy in good general condition with typical left drop wrist. There was atrophy of the left upper extremity below the elbow and patient was unable to extend elbow and wrist and had only slight flexion of fingers. Muscle and nerve test showed partial reaction of degeneration of left musculo-spiral nerve. A cocked up splint was applied and physiotherapy was started consisting of: (1) whirlpool bath, (2) interrupted galvanic, (3) massage, and (4) exercises. Muscle and nerve test, taken January 26 shows complete recovery of function of left upper extremity.

Dr. Whitman presented a later result of an operation for giant-cell sarcoma of the head of the tibia which he had operated on last April. At that time the tumor which had broken through the cortex and formed a tense swelling on the upper and inner aspect of the tibia was symptomatically of about two years' duration. At the operation it was found to have invaded the head of the fibula and to have broken into the knee joint. The patient had resumed work last August. He had discarded the brace in November. At the present time the limb can be extended at knee to about 165 degrees and there is a range of motion of about 20 degrees. A small opening still persists but the patient has no pain. The x-ray picture shows that the cavity is now practically filled with new bone. The articulating surface of the tibia on the outer side lies about half an inch below the inner side on which the weight of the body is supported.

Dr. Whitman presented an operative result of an old fracture of the elbow in a boy of 15, of 10 years' duration and completely limiting extension at the elbow. At operation the external condyle was found to have been displaced anteriorly leaving the head of the radius without support. On removal of the displaced fragment the arm could be extended to 160 degrees and the result was very satisfactory.

Dr. R. C. Kahle—Post-Mortem Case Report—Multiple Fractures, Following Metastases of Carcinoma of Breast of Seven Years' Duration.

Dr. Kahle showed the x-rays of a patient, 49 years old, who states that while lying on her back for the past two years, due to weakness, she noticed snapping of the right thigh while bending the knee. This was accompanied by pain, swelling and deformity with inability to extend the leg and thigh.

This patient has been in perfect health until two years ago, she had a lump in the right breast which has been treated locally. Examination essentially negative except for typical formation of skin nodules, the size of pin-head to ¼ inch in diameter, in the region of the breast. The case, because of the great weakness, was treated by nursing care and plaster-of-Paris splint applied to the leg to prevent pain.

The points of interest were:—

1. Duration of carcinoma of right breast, seven years.
2. Lacking of clinical signs and symptoms of metastases throughout the lungs, liver and intestines.
3. Wide distribution of metastases to the bones.
4. Multiple spontaneous fractures and post-mortem fractures.
5. Attempt at bone repair.
6. Marked absorption of calcium salts of bone.

Dr. L. C. Wagner—Recurrent Endothelioma of Knee—Radical Operation.

This patient, 39 years old, was shown before this Conference in February, 1924. At that time, through a split patella incision a large tumor, the size of a hen's egg, was removed from the right knee. It arose from the synovial membrane and was attached by a pedicle to the outer capsule of the knee joint. In gross appearance it was that of a benign tumor. The pedicle was excised and a local removal done. It was classified as an endothelioma arising from the synovial membrane and was thought to be of a low malignancy.

Soon after the operation, a swelling was again noticed on the outer border of the right knee anterior to the lateral ligament. This was watched and steadily increased

in size until April, 1925, when a removal was again resorted to. He had no evidence of any metastases throughout the body.

Through a hockey incision on the outer border of the right knee, the tumor was located and a wide excision done, including the old capsule, external lateral ligament and the anterior border of the patella tendon. In all, about 3 x 6 inches of tissue was removed. The tumor had infiltrated by direct extension into the upper end of the tibia. The upper end of the tibia, including about one inch of the bone, was removed with a chisel. This tumor was connected to the capsule and evidently arose from the capsule. A large defect was left and the wound was closed by only sewing the skin together.

The patient made a normal recovery and began walking at the end of two weeks. He now has good function, no pain, and a perfectly stable knee. He is taking x-ray treatment. There is evidently no recurrence of the tumor.

CONFERENCE OF FEBRUARY, 1926

Dr. S. Kleinberg—Paraffinoma of Left Knee.

G. M., 38 years old, is presented because he had what I found to be a condition of rare occurrence, namely, paraffinoma of the knee. Eight years ago he injected about one ounce of liquid paraffin at several points. He then struck his knee with a board to increase the irritation. His knee became swollen and painful and caused disability. He was admitted to a local hospital in Italy where he was treated for several months for a synovitis. The symptoms in the knee subsided and he had no further trouble for several years. For the past five years he has had one attack a year during which, without any apparent cause, the knee became swollen and painful. Each attack except the last one subsided in about a fortnight. The last attack of swelling and pain and disability began about three months ago and has persisted.

Examination showed three very distinct masses, one on either side of the thigh. The outer tumor was removed on January 21, 1926, and those on the inner side were operated on February 15, 1926. All were removed without any difficulty. The tumors were attached to the skin and were in the superficial fascia. They were hard and cut like cartilage. The cut surface was white except for a few streaks of yellow. There were numerous blood vessels about the tumor but very few in its substance.

The microscopic sections show a fibrosis of the subcutaneous tissue. There is a large amount of connective tissue with numerous areas of infiltration with small round cells. There are no giant-cells and no epithelium lines vacuoles. There was no evidence of any residual paraffin.

Dr. I. Zadek—Solitary Bone Abscess Complicated by Malaria.

Dr. Zadek presented the case of D. B., seven years old, who was brought to the hospital on account of pain over the left shin. The onset of this pain was three weeks after patient had a number of boils in the gluteal region. This was three months prior to his first visit to the clinic. Pain situated two or three inches above the left ankle has been quite marked.

Examination, October 21, 1925, showed a child in good condition who walked with a limp on the left side. There was swelling of the soft parts in the position of the tibia, beginning about an inch above the ankle joint and extending upward for two and a half inches. Here there was marked local tenderness.

X-ray photograph showed a shadow the size of a large pea in the cortex of the tibia on the antero internal aspect. There was slight local periostitis.

He was operated on October 22, 1925, by Dr. Stephens. The periosteum was found thickened, measuring three-sixteenths of an inch. The focus was exposed which contained a substance resembling granulation tissue; no frank pus. The cavity was entirely obliterated with a chisel leaving a small saucerlike depression. The medullary cavity was not opened. The wound was closed without drainage. A culture was taken at the time of operation and also a specimen sent to the laboratory. The culture was

positive for staphylococcus aureus. The tissue removed showed inflammation. The incision became infected and the sutures were removed. Wet dressings were instituted and patient's temperature dropped to normal where it remained until the eighteenth day after operation when it rose to 102.4 and showed a subsequent elevation daily as high as 105. The child did not look ill, but was a bit drowsy. At this time the operated area showed no unusual reaction about it. Physical examination showed an enlarged spleen, a white blood count of 10,000 and 50% lymphocytes. No malarial parasites could be demonstrated.

November 20, 1925, quinine in 3 grain doses every fourth hour was begun and patient during his stay in the hospital showed no subsequent elevation beyond 101. On December 2, temperature reached normal where it remained until his discharge December 5.

Summary. While no malarial parasites were demonstrated, patient's course in the hospital,—with a high lymphocyte count, with a large palpable spleen with a firm edge, with a history of malaria in other members of the family, the patient living on Long Island, and his immediate response to quinine therapy,—warrants the diagnosis of malarial infection.

CONFERENCE OF MARCH, 1926

Dr. R. Whitman—Giant-Cell Sarcoma of Head of Tibia.

This was a patient 30 years of age who had symptoms of discomfort in the left knee for about three years and entered the hospital in December for giant-cell sarcoma affecting the inner and upper portion of the tibia. This was about the size of a tangerine. The contents were entirely removed, the interior scrubbed and rubbed with iodine. A portion of the cortex was then broken down and placed within the cavity and wound closed. The patient has since worn a brace; has been walking about and at the present time x-ray picture shows that the cavity has nearly been filled with new bone. There is no discomfort. There is complete extension and voluntary flexion to 90 degrees.

Dr. R. Whitman—Arthritis Deformans of Hip—Reconstruction Operation.

A man, 51 years of age, was admitted December 3, 1925, for advanced disease of the right hip. The symptoms of pain, stiffness and limited motion were typical and the x-ray picture showed extensive destructive changes in the joint.

The reconstruction operation was performed December 14, 1925, The plaster spica was removed one month later. He began to walk about in February. The pain has been entirely relieved. This operation is considered an alternative to arthrodesis, after which ankylosis is somewhat doubtful and deformity of the adduction type very common.

After the reconstruction operation there is little tendency to deformity and in many instances a fair range of motion is retained.

Dr. R. Whitman—Legg Operation for Abductor Paralysis.

Dr. Whitman presented a boy twelve years of age. The lower extremities had been extensively paralyzed during the epidemic of 1916 and several years later an astragalectomy had been performed on both feet. He was again admitted in October, 1925. His particular disability was insecurity of the left hip due to paralysis of the abductors and resulting deformity. For the insecurity of gait, the tensor fasciae femoris and a part of the sartorius muscles were transplanted to the femur according to the Legg method.

On the right side it was noted that the astragalectomy had failed to check dorsal flexion satisfactorily and there was a tendency toward varus. The tibialis anticus tendon was transplanted to the outer border of the foot. The tibia was then split from side to side to increase the antero posterior diameter of the articulating surface and between it and the tarsus a wedge taken from the tibia was inserted. The plaster supports were removed one month ago and the results of both operations were satisfactory.

DR. S. KLEINBERG—Retroperitoneal Abscess of Pelvis in a Male.

Dr. Kleinberg presented the case of H. L., twenty-two years old, admitted to the Hospital on February 9, 1926. Three days previously he fell a distance of about twenty feet and sustained multiple fractures of the left pubic bone. On his admission to the hospital he was in good general condition but unable to walk and unable to lift the left leg from the bed because of pain in the left pubic bone. Clinical and x-ray examinations showed a fracture of the ascending and descending ramus of the left pubic bone. There were no associated injuries of the abdomen. Micturition was neither difficult nor painful. A plaster-of-Paris pelvic girdle was applied for support. Three days after his admission and without any apparent cause this man's temperature rose to 104½. He complained of pain in the abdomen and of feeling generally very miserable. Examination showed that the patient looked very ill. The abdomen was distended and generally tender but there was no localized rigidity and no localized tenderness. Blood examination showed a moderate leukocytosis and an increase of the polynuclear cells. During the next four days his temperature gradually went down to normal, but the abdominal distension was very marked and the abdominal pain and tenderness persisted. There was at no time any localization of trouble in any part of the abdomen. He had frequent bowel movements and marked tenesmus. No bladder disturbance. Consultations were had with several of the Attending Staff and no definite diagnosis was made, except that we all surmised that the man had an infection of a retroperitoneal hematoma as the result of the injury. Operation was not advised as there was no indication of the site at which an operation should be performed. His temperature rose again and during the next few days it fluctuated between 100 and 102. On February 20 man passed a great deal of pus in his stool. His temperature promptly came down to normal and he felt immediately relieved of the abdominal pain and distension and the tenesmus. He has had an uneventful recovery since. This patient evidently had a retroperitoneal pelvic abscess resulting from an infected hematoma following the fracture of the left os pubis with a rupture of the abscess into the rectum.

DR. R. STEPHENS—Case of Fragillitis Ossium.

Dr. Stephens presented the case of L. G., age three and one half years, admitted to Hospital January 27, 1926.

Father and mother and one sister are normal.

Child had simple fractures of both femora at birth. Has had seven fractures in all, always of the femora, each time the fracture has healed kindly. The last one occurred yesterday.

Examination showed that patient has a rather large head, suggestive of hydrocephalus, sclerae are blue; marked anterior and outward bowing of upper end of both femora. Tenderness at middle of right femur. Some false motion, but no crepitus. X-ray picture shows a greenstick fracture about the middle of the femur and also shows the site of previous fractures and the marked bowing.

Plaster spica was applied. At the present time there is good union. The bowing naturally persists. Patient is to have braces for protection. Has been getting medical care and treatment for brittle bones. Correction of deformity is to be deferred.

DR. P. COLONNA—Sequestrectomy of Fibula with Regeneration.

Dr. Colonna presented two cases illustrating the regenerative powers of bone following sequestrectomy of the fibula.

First case was a girl of twelve years of age, who gave a history of having injured the right ankle in 1921. A few days after the initial injury she was admitted to the hospital and drainage over the point of localized tenderness was made. The process continued to spread, stripping the periosteum of the fibula almost its entire length so that several weeks after the first operation almost the entire shaft was removed *in toto* and the periosteal shell left undisturbed. Drainage continued for several months. Finally the wound completely healed and a series of x-rays showed the gradual but complete regeneration of the fibula.

Second case was a child of eight years of age. She was admitted to the hospital

following a blow against the outer aspect of the right leg and ran a somewhat similar course to the preceding case except that the entire length of the fibula shaft became loosened and was completely withdrawn with very slight traction from the wound made at the external malleolus leaving a periosteal tube in which Dakin tubes were placed. This child was operated on in 1924 and at the present about two-thirds of the shaft of the fibula has regenerated. In both cases the wounds are completely closed. There is no localized tenderness and the patients are having no trouble whatsoever.

CONFERENCE OF APRIL, 1926

DR. B. L. COLEY—Multiple Fibromata.

Dr. Coley presented the case of a man fifty-six years of age. First noticed a lump below the knee cap on the left side about twelve years ago. This has grown progressively in size and since then other nodules have appeared as follows:

One over the right pre-patellar, one over the extensor surface of each elbow and a similar one adjacent to the large one on the right elbow and one deeply situated in the hypothenar eminence of the left hand. These have given the patient no pain. He states they have progessively but slowly increased in size and he seeks operative relief because he thinks they are unsightly. They were removed April 13, and photographs taken illustrating the condition.

Microscopic diagnosis by Dr. Jeffries in each instance was fibromata.

DR. J. BUCHMAN—Vertebral Epiphysitis.

Dr. Buchman presented Rose B., age 15. She stated when seen in the Out Patient Department that sixteen months ago pain appeared in the back and that she was readily fatigued. Four months ago she suffered from chorea. When first seen by Dr. Balensweig, she presented a slight round back and a flattening of the lumbar spine. He referred her to the neurologist who treated her for chorea with rest in bed, diet and arsenic. After several weeks she improved considerably. Two months later she came under my observation. She then complained of pain in the back, round shoulders and nervousness. Examination revealed a poorly nourished, rather anaemic, restless child presenting a moderate degree of posterior curvature in the dorsal region, exaggerated lordosis of the lumbar region and a slight deviation of the dorsal spine to the left. All motions of the spine were free save extension in the dorsal region. The dorsal and lumbar spinous and transverse processes and iliac crests were tender. X-ray examination showed a slight left dorsal curve. The lower six dorsal intervertebral spaces were all hazy, indistinct and mottled. The lateral view showed an increased kyphosis in the dorsal region and an exaggerated lumbar lordosis. The outlines of the dorsal vertebrae were irregular and the bodies appeared rarefied and mottled. The intervertebral spaces were hazy and mottled. A diagnosis of kyphoscoliosis secondary to vertebral epiphysitis was made and frame treatment was advised.

Six weeks later the patient was admitted to the Hospital and frame treatment was instituted. After eight weeks of rest on a convex frame, baking and light massage of back and extremities, and tonsillectomy, the posterior curvature was entirely corrected and her pains which at one time involved all of her bones and joints disappeared, the chorea practically cleared up and the child improved generally. At the end of this period a plaster-of-Paris jacket was applied but had to be removed on account of pain. She was then given a pelvic girdle with shoulder straps.

About one month later the patient returned to the Out Patient Department stating that the pains have recurred and that her restlessness has returned. Examination revealed tenderness of the spinous processes in the interscapular and lumbar regions of the spine.

The case was presented because it demonstrated:

1. The active stage of vertebral epiphysitis with acute pains.
2. The early stage of spinal deformity.
3. The efficacy of frame treatment in the control of pains and deformity.
4. The inadequacy of ambulant support and treatment.

DR. I. ZADEK—Astragalectomy for Ankylosis in Calcaneus.

Dr. Zadek presented M. P., age 29 years, who was admitted to the Hospital for Ruptured and Crippled November 10, 1925, with a history of infantile paralysis at the age of four years. At the age of eight years, she was operated upon in France and an arthrodesis was performed on the right ankle.

On admission the foot was found fixed in an attitude of calcaneo-cavo-varus. At this time there was demonstrable power only in the short flexors of the toes. Patient walked with a typical heel gait. X-ray photograph showed bony ankylosis between the astragalus and the lower end of the tibia, as well as between the astragalus and both malleoli.

Operation was performed November 12, 1925. Incision was made over the front of the ankle joint, and the astragalus outlined and separated from the malleoli and the lower end of the tibia by means of an osteotome and mallet. Next the usual astragalectomy incision was made on the outer side of the ankle. Peroneal tendons were retracted and the astragalus removed. Foot displaced well backward. Plaster-of-Paris was applied with the foot in an attitude of equino-valgus.

April 29, 1926. Patient is now walking with an ankle brace in a drop foot attitude and limited joint at the ankle. Is able to walk without the brace. There has been return of function in several of the muscles about the ankle, the calf muscle particularly, and patient has twenty degrees movement in the ankle. Dorsal flexion is checked at a right angle. The movement, as well as walking, is painless.

DR. R. STEPHENS—Fracture of Spine of Tibia.

Dr. Stephens presented the case of G. P., age 34 years. Injured left knee in August, 1925. Was standing with knee flexed to about a right angle, when a large stone rolled against the front of his leg. Was treated for some time apparently as a case of internal derangement of the knee joint or strain.

Dr. Stephens saw him in December, 1925, and found that he had pain, limitation of extension to 170 degrees with severe pain on any attempt at further extension. No increase in fluid or lateral mobility. Some tenderness directly under patellar ligament. Diagnosis of fracture of spine of tibia was made and confirmed by x-ray. Diagnosis was made on—

1. Type of injury.
2. Point of tenderness.
3. Limitation of extension.
4. X-ray.

Operation was advised but delayed until this time. Patient was admitted to the Hospital for Ruptured and Crippled on April 9, 1926, at which time the examination and x-ray were the same as in December, 1925.

The x-ray shows the fracture of the entire spine of the left tibia. Operation: The joint was opened through a long incision just internal to the patella. Two fragments were removed, one projecting up near the anterior end of the internal semilunar cartilage and the other at the anterior rim of the tibia and partially in the insertion of the anterior crucial ligament. Both were united with fibrous tissue and not bone. The free portion of the anterior crucial ligament was sutured down with fine chromic catgut and the wound closed in layers.

Recovery was really uneventful. Temperature was from 100 to 101 for about ten days but wound healed *per primum*. Active motion was allowed but not encouraged. After two weeks walking was begun and physiotherapy given.

Current Literature

FRACTURES OF THE HEAD OF THE FEMUR: Frederick Christopher, M. D. *Archives of Surgery*, May, 1926, p. 1049.

Fractures of the head of the femur are said to be very rare, only fourteen having been recorded. The author adds the report of another case, and abstracts those previously reported in the literature.

The fracture usually results from extreme violence and is almost always associated with a posterior dislocation. This complication makes diagnosis extremely difficult so that x-ray examination or actual inspection of the site of injury is necessary for positive diagnosis. In most of the cases, treatment, which consists of reduction of the dislocation followed by early mobilization, resulted in only fair function recovery. In some cases operative removal of the fragments is necessary.—*I. Wm. Nachlas, Baltimore, Md.*

THE TREATMENT OF OLD CONGENITAL DISLOCATION OF THE HIP, WITH SPECIAL REFERENCE TO THE USE OF SKELETAL TRACTION BEFORE REDUCTION BY OPERATION. LeRoy C. Abbott, M. D. *Archives of Surgery*, May, 1926, p. 983.

The author reports six cases of dislocation of the hip in children between ten and sixteen years of age. Of these only four were congenital in type. The other two resulted from contractures following anterior poliomyelitis.

Stress is laid on the difficulty in reducing such dislocations because of the contractures of the soft parts and the changes in the acetabulum. The first of these difficulties he overcomes by skeletal traction, the latter by open operation. After the hip has been exposed the appearance of the acetabulum and head of the femur determine the exact procedure to be followed.

For some cases Abbott advises arthrodesis, for others he attempts to gain a movable hip. He leaves one with the impression that reduction followed by ankylosis gives the better functional result.—*I. Wm. Nachlas, Baltimore, Md.*

A SIMPLE MEASURE METHOD OF THE HIGH TROCHANTER: Karl Bragard, (Munich). *Ztschr. f. orthop. Chir.*, XLVII, 2, 232, February 15, 1926.

A lead tape is placed along the crest of the ilia and the point of the trochanter which is still palpable to the finger is marked. Then the legs are slightly spread and a caliper is applied—one point touching the wire and the other the tuber ischii, the caliper being held perpendicular to the wire. Then the legs are adducted and in the same manner the distance is read between the marked trochanter and the wire along the crest. The comparison of the readings on both sides gives changes in the height of the trochanter. The method has been tried by the author on more than 100 cases and the margin of error was found to be less than one-half centimeter.—*A. Steindler, Iowa City, Ia.*

THE SCOLIOTIC PROBLEM: Dr. Hugo Maass. *Ztschr. f. orthop. Chir.*, XLVII, 2, 212, February 15, 1926.

The article contains nothing essentially new regarding the pathogenesis of scoliosis but reviews concisely a series of etiological factors.

The vertebral column is eminently predisposed to mechanical disturbances of growth because of its multiplicity of zones of enchondrial growth. Its growth in length results from the activity of its twenty-four osteogenetic zones of the separate vertebral bodies as well as from the secondary seats of enchondrial growth which take care of the circumferential increase of the bodies as well as the growth of the arches

and the articular and transverse processes. In this abundance of growing zones undoubtedly lies the principal reason for the frequency of spinal curvatures especially of the habitual scoliotic.

The occasion for growth disturbance is furnished by the erect position of the body.

The author distinguishes between the vegetative and the dynamic growth. For the vegetative growth the upright position is of no consequence. The clinical experience that children who are bedfast for a long period of time, apparently grow rapidly seems to bear out this point. The mechanical or dynamic growth of the spine, however, is influenced by external forces and muscular activity. As soon as the weight-bearing pressure upon the spinal column becomes asymmetrical such as is the case in faulty postures the growth zones of the vertebrae experience pressure stress at the concavity and tension stress at the convexity of the curved spine.

If this asymmetry works with sufficient intensity and sufficiently long, then the effect of unequal pressure may find its expression in the formation of oblique or cuneiform vertebral bodies.

By means of this distinction between vegetative and mechanical growth which seems to be rather artificial, the author believes that the confusion existing in the literature about pressure atrophy and functional hypertrophy may be cleared.

The so-called dynamic changes in form are really architectonic or structural deviations which under the law of functional adaptation develop with the regularity of mechanical and dynamic laws.

It seems to the author that the scoliotic spine is excellent proof of his contention that the pathologic pressure and tension stresses do not produce reaction in the vegetative growth zones but in the zones of enchondrial and periosteal growth, by way of transformation entirely subject to the simple laws of mechanics and dynamics.

It must be remembered that the asymmetry of the scoliotic vertebrae is not strictly lateral but diagonal, corresponding to the scoliotic posture which is not a pure lateral deviation but a rotation of the vertebral column as well.

The result is that the body is more weighted down than the arches; the vertebrae within the curve, rotating toward the convexity, carry the maximum of pathologic pressure upon the posterior concave side quadrant of the body. Consequently it is here where we find the greatest reduction in height, the greatest condensation of texture, and the greatest amount of flattening of the vertebrae.

It seems natural to accept for the severe scoliosis of the school age a pathologic degree of softness of the bone, a conception for which the x-ray investigations of Looser have furnished considerable proof. But the author turns against generalization of this point in the explanation of the adolescent scoliosis and refuses to accept rachitis tarda as a general cause of scoliosis.

Böhm and others have called attention to congenital anomalies of the spine and thorax and a good deal of importance has been attributed to this factor in the formation of scoliosis. The author does not believe that this is a frequent cause. In the first place it has been shown that congenital anomalies of the vertebrae by no means always produce scoliosis and that, moreover, congenital asymmetry of single vertebra may be equalized with progressing growth. Then also, it is hard to see why congenital anomalies should not manifest their deforming influence until the school age is reached.

It seems to the author that the cause for habitual scoliosis in the great majority of cases is to be found neither in pathologic softness of bone nor in congenital anomalies, but in the mechanical effect of the upright position which taxes the spine, endowed with a multitude of mechanical growth centers, with an unusual degree of resistance.

Especially in children who are constitutionally below par it cannot be surprising to see the growth energy of the spine give out under the constant static stress. So he comes to the conclusion that the pathologically decreased mechanical growth energy of the bone is the real cause of the collapse of the spine and the production of scoliosis.

He does not deny the existence of other factors, especially that of hereditary and endocrine disturbances; but he accords them importance so far as they influence what

he terms the mechanical growth energy of the bone, substituting a clearly conceived but rather abstract term for a number of rather obscure histological factors.—*A. Steindler, Iowa City, Ia.*

REMOVAL OF HAMMERTOE BY JUXTA-CAPITULAR RESECTION OF THE BASAL PHALANX: Karl Bragard, (Munich). *Ztschr. f. orthop. Chir.*, XLVII, 2, 283, February 15, 1926.

An incision two centimeters long is made on the dorsal surface of the basal phalanx from behind the head of the phalanx upward. From three-eighths to one-half inch of the distal end of the shaft is resected subperiosteally—the planes running slightly from dorsal and proximal to plantar and distal. If necessary a wedge-shaped piece of the shaft may be resected; this allows easy extension of the middle phalanx. The hyperextended proximal phalangeal joint can be corrected by incision of the dorsal and lateral portion of the capsule of the metacarpal phalangeal joints. A splint with traction on the end of the toes is applied. After ten to twelve days the sutures are removed. Three or four weeks after the osteotomy has healed the patient wears a Lange arch support with anterior convexity to raise the anterior arch.—*A. Steindler, Iowa City, Iowa.*

WEDGE- SHAPED VERTEBRAE AND PARALYSIS: H. Salis, Basel. *Ztschr. f. orthop. Chir.*, XLVII, 2, 275, February 15, 1926.

The author reports a case of paralysis of the right hand with advanced muscular torticollis of the right side and congenital scoliosis due to wedge formation of the seventh cervical and fourth dorsal vertebrae. The literature on the subject is reviewed extensively. He believes that cervical scoliosis was responsible for the paralysis of the right arm as well as the existing Horner's syndrome by virtue of the pressure upon the cervical nerve roots and the sympathetic nerve. It was treated by redressment of the torticollis followed by a collar.—*A. Steindler, Iowa City, Iowa.*

THE EFFECT OF SUBCORTICAL MECHANISMS UPON THE FORMATION OF POSTURAL ANOMALIES AND DEFORMITIES OF THE SPINE WITH SPECIAL CONSIDERATION OF THE SEQUELAE OF ENCEPHALITIS EPIDEMICA: Gunther Winkler, (Breslau). *Ztschr. f. orthop. Chir.*, XLVII, 2, 236, February 15, 1926.

The favorite localization of the chronic form of epidemic encephalitis is the corpus striatum. We distinguish corpus striatum in the stricter sense, which includes the nucleus caudatus and putamen, and the globus pallidus which forms the medial section of the nucleus lentiformis, but while topographically belonging to the latter is quite different in histological, physiological, ontogenetic and phylogenetic respects.

We are now in possession of enough facts to make a clear distinction between the pathological changes of the two portions of the corpus striatum. According to Stertz we distinguish between a dystonic-hyperkinetic and hypertonic-akinetic symptom complex.

Considering the first group it may be stated that most of the hyperkinetic syndrome such as chorea, motor unrest, etc., occur in the acute stage of encephalitis and either subside or remain in attenuated form as residual symptoms.

Among these hyperkineses we distingui h the choreatic and athetotic movements, the myoclonic contractures, and the torsion spasms. The choreatic and the athetotic are well known and described in connection with Sydenham's chorea.

The myoclonic contractures are rhythmic or arhythmic muscular contractures with or without locomotor effect.

Less frequent than the former are the torsion spasms which nevertheless are of great interest to the orthopaedic surgeons, especially since they may be responsible for spinal deformities.

According to O. Foerster these muscle spasms will cause sudden movements such as extension or flexion of trunk, extension, flexion or rotation of the head or spastic extension in hip, knee, and ankle joint.

It is peculiar that these movements occur by action of certain synergistic groups such as the extensors of the hip, extensors of the knee, and plantar flexors of the ankle.

There is, furthermore, a tendency to continued spastic attitudes, attitudes of posture. If the spasms are localized in the upper cervical musculature, the spastic torticollis may result.

In all these forms there is a striking similarity with muscular syndromes of emotional expression or of reactive defence. Foerster emphasizes the connection between the athetosis of the fingers with the climbing and gripping movements of the apes. Attitudes of flight, of defence, of vigilance seen in animals may be represented in these hyperkinetic movements of encephalitis.

The present conception of the mechanism of these movements is based upon the assumption that all concomitant and reactive movements have their center of coordination in the so-called extra-pyramidal system comprising the globus pallidus and also some of the cerebellar nuclei. This represents a central system of its own independent of the pyramidal system.

Now coming back to the corpus striatum in the stricter sense and to the nuclei pallidus, according to pathological and anatomical investigations there is in all hyperkinetic syndromes a pathological process in the corpus striatum proper.

The nucleus caudatus and putamen are supposed to have an inhibiting influence upon the globus pallidus and upon the nucleus rober of the cerebellum. If these centers are diseased there occurs a release of inhibition under which the extrapyramidal centers now work without restraint. The result is the described syndrome of hyperkinesis.

Histologically there is a great difference between the globus pallidus on one side, and putamen and nucleus caudatus on the other. The latter nuclei show small cells with short dendrites splitting up within the corpus striatum and the large multipolar cell with long dendrites radiating into the globus pallidus. The globus pallidus, on the other hand, has only large cells. These two types of nuclei, differ ontogenetically and phylogenetically, the globus pallidus being present in lower animals while the others appear only from the reptiles upward. The newborn child with the pyramidal tract and the later portion of the corpus striatum not yet fully developed shows in its athetotic movements the dominant influence of the globus pallidus.

The second type of post-encephalitic motor disturbances shows the akinetic-hypertonic syndrome and is caused by disturbance in the globus pallidus. In contrast to the former group, the cardinal symptom here is lack of motion. The arms of the patient are held stiffly to the side. Gait and attitude show a peculiar rigidity which is also seen in the muscles of the face. The lines of the expression are obliterated, the mimic play of the face is gone. The time of reaction is increased. Positions once assumed are retained for a certain length of time (the so-called fixation of Strümpell, pseudocataleptic attitude), a motion once instituted does not resolve itself. The patient once breaking into a laugh retains the facial expression for minutes at a time. Typical also for globus pallidus lesions are the phenomena for propulsion and retropulsion. The patients set in motion will stumble forward before they can arrest themselves—they cannot answer promptly a certain impulse to straighten the body. There is no staggering or falling as in cerebellar lesions but the symptom of adiadokokinesis, so typical for cerebellar foci is also present in lesions of the corpus pallidus. The speech is peculiarly slow and monotonous; and the handwriting is characterized by the extreme smallness of the letters (micrography).

The most typical syndrome of corpus pallidum involvement is the hypertony which involves especially the proximal joints; there is an increased tonus, a so-called waxlike flexibility, especially in the elbow joints. Of great interest for the orthopaedic surgeon are the posture anomalies of the spine. The head is stretched forward with slight lordosis of the cervical spine, the dorsal spine is kyphotic and the lumbar spine, lordotic. The impulse of automatic straightening of the spine is missing.

The pathological investigations reveal, aside from occasional edema and slight hemorrhage into the gray substance and meninges, definite microscopic changes; there are inflammatory infiltrations with accumulations of lymphocytes and reactive changes

of the glia as well as degenerative changes in the ganglion cells to be found in the corpus striatum and optic thalmus as well as in the red neucleus. Degenerative changes have been found diffused over the entire central nervous system. In later cases there is found chronic indurative changes in caudatus, putamen, and pallidum.

From these observations there is left no doubt of the effect of epidemic encephalitis upon the passive locomotor apparatus with its contingent interest to the orthopaedic surgeon.

The author has observed and describes minutely four cases of postural anomalies and deformities of the spine following encephalitis.

In one case the lesion was assumed to be in the globus pallidus with accompanying Parkinsonism producing the described motor arrest and causing the spine to remain in the slump position.

In another case the syndrome was dominated by torsion spasm of the left lower extremity with spasms of the extensors of the hip, of the elevator of the left half of the pelvis so that marked lordosis and obliquity of the pelvis resulted. In these cases the lesion was in the corpus striatum in the stricter sense and consequently the author distinguishes two definite lesions in regard to the spinal deformities:

First, pallidum symptoms (2 cases), in which automatic erection of the spine was inhibited and there was wax-like rigidity.

Second, striatum symptoms with continuous spasm of the musculature of the trunk.—*A. Steindler, Iowa City, Iowa.*

Technic of Use of Removable Radon Seeds in Carcinoma of the Tongue. Joseph Muir. *Annals of Surgery*, May, 1926, LXXXIII, p. 598.

This article describes a new technique of radium therapy in lingual carcinoma which offers a practical means of irradiating even the most inaccessible tongue lesions. This is accomplished by the implantation of removable platinum radon seeds. As the methods of treatment heretofore used have always proved unsatisfactory, this article is of especial importance from a clinical standpoint.

The various methods by which lingual carcinoma has previously been treated are discussed and their advantages and drawbacks considered. Imbedding of bare tubes according to Janeway's method affords an even distribution of radiation, but causes necrosis which is invariably followed by sloughing and may even induce unavoidable fatal hemorrhage. If screened seeds are used, necrosis is avoided, but they are objectionable because they must remain in the tongue as foreign bodies. The platinum needles advocated by Regaud also obviate necrosis and can be removed when radiation has been accomplished, but proper distribution of these applicators is very difficult; they cause too much trauma; and above all, they are hard to immobilize and cannot be placed upon the posterior dorsal surface of the tongue.

The method offered in this article obviates all these difficulties, while retaining every desirable feature. The seeds are completely screened with platinum, thus doing away with necrosis and sloughing; they are easily withdrawn after adequate dosage has been delivered, so that they do not remain in the tissue as foreign bodies. These seeds can be placed in any position required, just as readily in the hitherto inaccessible "root" of the tongue, as in more favorable positions. The article is profusely illustrated, demonstrating the exact method of approach to these inaccessible lesions.

The growth is first carefully palpated, and the number of seeds required determined according to its depth and surface extent. When a seed has been placed in the desired position, the attached thread is left protruding from the point of entry, where it is cut off so as to leave just enough to be readily grasped with forceps at the time of removal.

The entire treatment causes no pain, and but slight inconvenience to the patient; and when skillfully performed under proper aseptic precautions, the technique offers an excellent means of solving one of the most vexing of clinical problems.—*Joseph Muir.*

Note: The treatment described above may be of interest because of its possible use in bone surgery.—*Editor*